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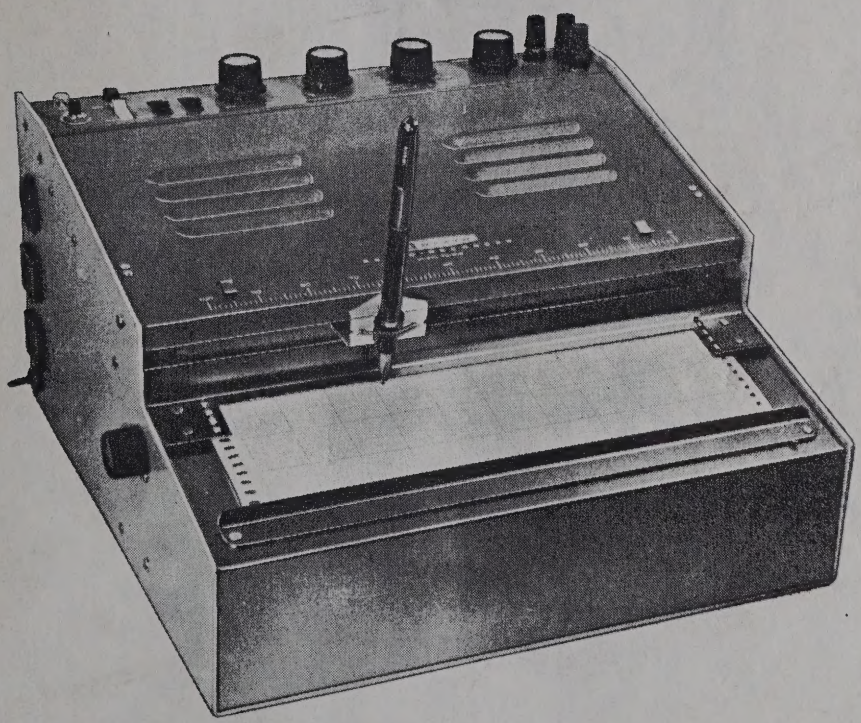
THE

HEATH

SERVO RECORDER

MODEL EU-20B



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BENTON HARBOR, MICHIGAN 49022

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SPECIFICATIONS

Chart Paper	Grid Width: 10" Length: 120 foot roll. Markings: 0-100, right to left
Chart Speed	2 inches per minute; additional motors for special chart speeds are available from Heath Company; see Page 19.
Chart Span	Five fixed ranges: 10, 25, 50, 100, and 250 mV; plus a vernier adjustment between each fixed range, which provides adjustment of span to any value between 250 and 3.3 mV. There is also an External position for special plug-in fixed ranges.
Pen	Standard fountain pen, cartridge type.
Balancing Time	0.1 second per inch, 1 second full scale (10"). (50 Hz, 1.5 seconds full scale).
Input Circuit	Self-balancing potentiometric on all ranges.
Input Resistance	Essentially infinite at null. Approximately 500 kΩ off null.
Line Frequency Rejection	80 dB in common mode.
Floating Input	100 V DC maximum above ground. 70 VAC rms maximum across the negative (-) input terminal and GND terminal.
Overall Error	Less than 1% of full scale from 10 to 250 mV.
Dead Zone	Less than 0.5% of full scale from 10 to 250 mV.
Linearity	Less than 0.5% full scale.
Maximum Recommended Source Resistance	50 kΩ.
Reference Source	Zener regulated supply.
Accessory Sockets	10 watts may be drawn from each socket at 120 VAC, 10 watts total may be drawn at 240 VAC. 6.3 VAC at 50 mA may be drawn from the Accessory 11-pin socket.
Power Requirements	120/240 volts, 60 Hz; 45 watts. (120/240 volts, 50 Hz; 50 watts.)
Fuse	1 ampere slow-blow (120 VAC). 1/2 ampere slow-blow (240 VAC).
Dimensions	14" wide x 8-3/4" high x 13-1/4" deep.
Net Weight	17 lbs.

INTRODUCTION

The Heath Model EU-20B Servo-Recorder offers several unique features found in no other unit. In normal operation it is a precision laboratory-type self-balancing potentiometric recorder which can be used to record pressure, speed, temperature, strain, pH, light radiation, and many other phenomena when connected to suitable signal sources. It is also easily modified for multi-purpose applications as a servo system. It can be quickly connected for use as a servo constant-current source, a self-balancing Wheatstone bridge, an integrating recorder, a recording microammeter, and other servo-devices.

Three 5-pin plugs enable you to rapidly modify the Recorder for use in new research and development problems that require a sensitive, fast response, recording servo system.

An 11-pin Accessory socket and two standard 120 volt Power sockets are provided on the side of the Recorder (see Figure 1A) for remote operation. The starting and stopping of other instruments can be synchronized with the Servo and Chart switches, and the Recorder itself can be operated by remote switching from another instrument.

A floating input is obtained when you remove the shorting strap which connects the negative (-) input terminal to the GND terminal. This allows you to connect a signal source to the Recorder input terminals even though the signal source and Recorder have different ground potentials.

The unique layout and connector system in this unit enable you to quickly test servo solutions to research and development problems and put them to use. This Recorder is truly a multipurpose instrument. In addition to its use as a precision measurement and control device, it serves as an ideal educational unit for learning about servo mechanisms.

Servo and Chart switch circuits make it possible for you to operate the chart drive and servo mechanisms independently of each other or simultaneously. The Recorder may also be turned on without supplying drive voltages to the chopper; thereby conserving the limited chopper life.

The pen holder was designed to accept many different styles and types of pens, including the felt and fiber tip pens. This unique feature will also enable you to obtain multicolored plots by using colored pens. The impedance-reduction damping feature of the Recorder makes it possible to introduce damping into the servo system without appreciably increasing the dead zone. Optional, easily-changed chart speed motors are also available (see Page 19).

THE MALMSTADT-ENKE INSTRUMENTATION LABORATORY

This instrument is one of the units included in The Malmstadt-Enke Instrumentation Laboratory. It is available as an individual unit, or it can be purchased at a special group price when included with the total system. The units of the complete Laboratory Station are useful not only in learning electronic concepts, but also in research and development, and control instrumentation.

OPERATION

CONTROLS AND INPUT TERMINALS

Before operating the Recorder, read the following information to familiarize yourself with the operation of the controls. Refer to Figures 1A and 1B.

Rocker Switches

POWER. . .Connects 6.3 volts AC to the filaments and B+ voltage to the voltage amplifiers. This switch, and only this switch, should be in the ON position when the Recorder is to be operated at intervals and kept ready for instant use. While in this standby mode, 120 volts AC is available at pins 1 and 2 of the 11-pin Accessory Power socket. 6.3 volts AC is also available at pins 9 and 10.

SERVO. . .Connects 120 volts AC to the servo motor, B+ to the power amplifier for the servo motor, and 6.3 volts AC to the chopper. This allows the Recorder to be zeroed and calibrated without the chart paper moving. With this switch in the ON position, 120 volts AC is connected to the bottom AC socket and to pins 1 and 3 of the Accessory Power socket. 6.3 volts AC is also connected to pins 10 and 11 of the Accessory Power socket.

CHART. . .Applies power to the chart drive motor. In the ON position, 120 volts AC is connected to the top AC socket and to pins 1 and 4 of the Accessory Power socket.

Damping Control

The DAMPING control adjusts the output impedance of the power amplifier by varying the amount of feedback. Increasing damping just to the point that prevents excessive overshoot or oscillation of the marking pen provides greater control over the servo motor and, therefore, maximum accuracy. The DAMPING control must be readjusted each time the span is changed.

NOTE: Too much damping will reduce the amplifier gain to where the dead zone will be excessive. Use only enough damping to stop oscillations of the pen.

Full Scale Sensitivity Controls

The SENSITIVITY switch along with the VERNIER SENSITIVITY control determines the full scale sensitivity of the Recorder. The switch has five fixed positions and an EXTERNAL position. In the EXTERNAL position, a voltage divider network can be used for special applications. See External Range Socket on Page 15. In order to use the fixed sensitivity positions, the VERNIER SENSITIVITY control must be fully counterclockwise.

The VERNIER SENSITIVITY control allows you to adjust each fixed full-scale sensitivity position to increase the sensititivity up to three times. For example, the 100 mV position can be increased in sensitivity to about 33 mV.

Zero Position Control

This control allows the zero point to be set at any position on the chart paper between zero and 100. To extend the range of the ZERO POSITION control, see Zero Suppress on Page 14.

Input Terminals

The negative (-) Input Terminal must always be connected to the "low side" of the input signal being measured. The positive (+) Terminal should be connected to the "high side" of the input signal.

The wire connected to the positive (+) Terminal may have to be shielded in some cases to keep high 60 Hz AC fields from entering the Recorder. This 60 Hz noise would be indicated on the chart paper by a large dead zone and a bright glow of the 60 ~ Indicator lamp during null balanced conditions. Adjustment of the null control will often counteract a moderate 60 Hz input signal.

A positive-going signal applied to the Recorder will cause the marking pen to scan from right to left. It is also possible to scan from left to right, as described under Wiring Changes To Reverse Pen Travel on Page 13.

The negative (-) Input Terminal and the GND Terminal will normally be connected together by a shorting strap that connects the negative (-) input terminal to chassis ground. However, a floating input can be obtained by removing the shorting strap; the input terminals can then be operated at up to a maximum of 100 volts DC above ground. A floating input will prevent ground loop currents when recording or measuring a grounded signal source.

The Recorder is equipped with a three-wire line cord with the third wire connected to the chassis. Therefore, before connecting any equipment to the Input Terminals, check for grounding conflicts between the Recorder and the equipment being measured. In some cases, it may be necessary to remove the chassis from ground potential. This can be accomplished by removing the sheet metal screw located in the lower right-hand corner of the chassis. The ground wire can then be removed from the chassis so the chassis will no longer be at ground potential.

Calibrate Control

With the CALIBRATE control adjusted on the 100 mV fixed sensitivity position, all other positions will be within 1% of full scale. For maximum accuracy, the CALIBRATE control can be adjusted for the particular position being used. NOTE: The VERNIER SENSITIVITY control must be fully counterclockwise when calibrating the fixed sensitivity positions.

Paper Feed Knob

The PAPER FEED knob is used to manually advance the chart paper.

60 Hz Null Control

For the initial 60 Hz null adjustment, connect the input terminals together with a short wire. Then place the SENSITIVITY switch in the 10 mV position and turn the VERNIER SENSITIVITY control fully counterclockwise. Adjust the DAMPING control for a minimum amount of damping, and turn the NULL control for minimum glow of the neon 60~ Indicator lamp.

The preceding adjustments will be adequate for most Recorder operations. However, if the 60~ Indicator lamp glows brightly at null balance after you connect the Recorder into a setup, it is indicating that 60 Hz is applied at the input of the Recorder. A 60 Hz filter may be used at the input terminals to reduce this 60 Hz signal as described in the Applications section of the Manual.

For maximum accuracy and minimum dead zone, the NULL control should be readjusted each time the sensitivity on the Recorder setup is changed. This should be done with the Recorder operating at null balance.

PAPER LOADING

Refer to Figure 2.

1. Remove the pen from the pen carriage.
2. Remove the access panel by lifting it at the front edge.
3. Remove the chart roll spindle by first centering it in the vertical slots of the spindle holders; then lift it straight up and out of the spindle holders.
4. Place the spindle through the center of the chart paper roll.
5. Replace the chart roll spindle in the spindle holders with the paper positioned so it rolls off the spindle from the bottom, as shown.
6. Refer to Figure 2 and insert the chart paper under the paper guide. Turn the PAPER FEED knob on the side of the Recorder until the perforations on each side mesh with the paper drive sprockets. Feed the paper under the paper tear off plate.
7. Place the POWER and CHART switches in the ON position. The paper drive sprockets will pull the chart paper under the paper guide.

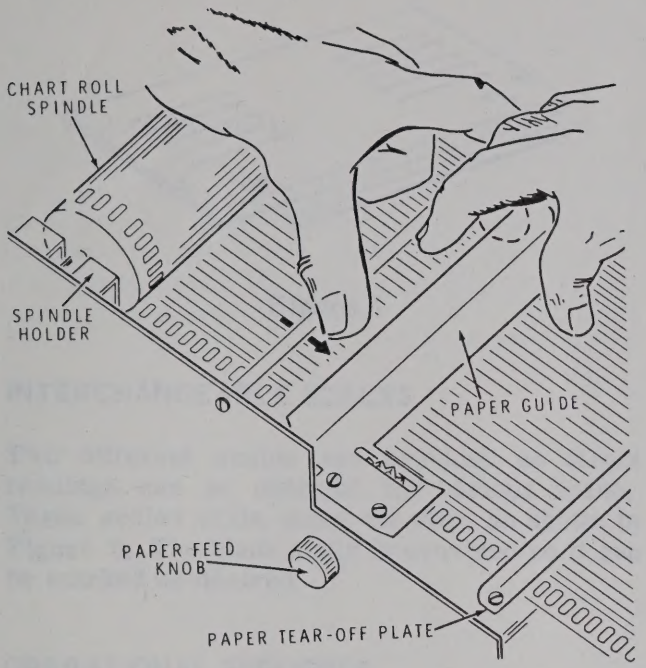


Figure 2

PEN INSTALLATION

The pen supplied with the Recorder is a standard fine point cartridge-type fountain pen. The pen carriage is designed so that when the Recorder is not in use, the pen can be stored upside down in the pen carriage with the cap on. This keeps the ink from drying on the pen point and prevents the point from being damaged.

To place the pen in operation, remove it from the pen carriage and remove the cap from the pen. Then insert the point end of the pen into the pen carriage until the pen carriage clears the paper guide as shown in Figure 3.

When using a new pen for the first time, you may experience an excessive flow of ink from the tip (bleeding). To cure this problem, the tip must be aged by leaving it uncapped for about 1/2 hour and allowing the ink in the tip to dry out. The dried ink will deposit in the tip and reduce the flow of fresh ink. After the ink is dry, the tip must be reprimed by holding the pen in a vertical position and lightly tapping the tip on a piece of paper. Now, the ink should flow properly.

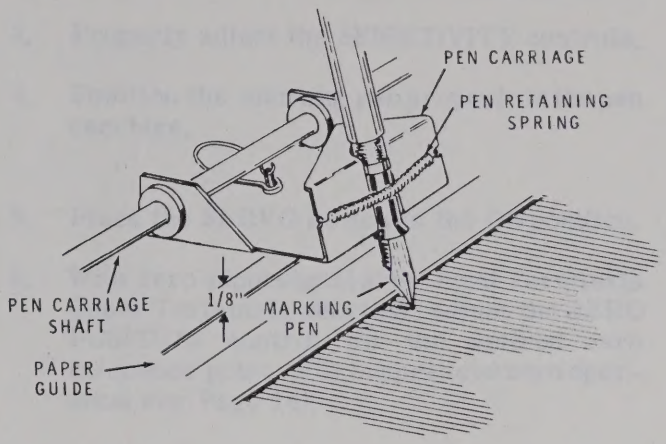


Figure 3

The pen tip may also dry out when recording with slow chart speeds for long periods of time. This, of course, is undesirable. However, it can be remedied by improvising a shield which covers the pen tip area and exposes just the writing nib. See Figure 4. The shield may be made from a piece of plastic tubing, tape, or even a modified pen cap. The shield will keep the air away from the tip and keep the tip from drying out. If the pen tip dries out and becomes clogged, it can be cleaned by rinsing it out in plain water.

The use of standard, easily-obtained, cartridge-type pens make it possible for you to obtain multicolored plots merely by changing the pens.

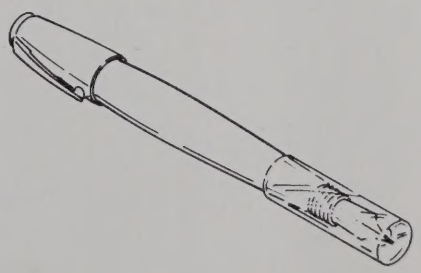


Figure 4

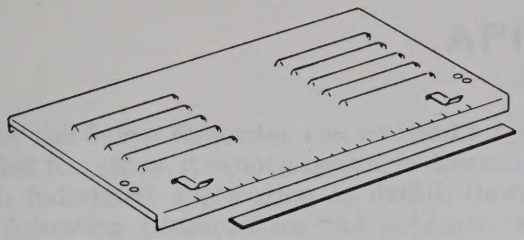


Figure 5

INTERCHANGEABLE SCALES

Two different scales are provided so direct readings can be obtained for various spans. These scales slide under the clips as shown in Figure 5. The blank scale is provided so it can be marked as desired.

OPERATIONAL SEQUENCE

1. Place the POWER switch in the ON position and allow a few minutes for warmup.
2. Install the chart paper in the Recorder.
3. Properly adjust the SENSITIVITY controls.
4. Position the marking pen properly in the pen carriage.
5. Place the SERVO switch in the ON position.
6. With zero input signal at the Input Terminals (Input Terminals shorted), adjust the ZERO POSITION control for the desired zero reference point. (For suppressed zero operation see Page 14).
7. Adjust the DAMPING control for proper damping.
8. Connect the DC signal source to the input terminals.
9. If necessary, adjust the NULL control for minimum glow of the Indicator lamp.
10. Place the CHART switch in the ON position. The Recorder is now recording the input signal.

APPLICATIONS

Since the Servo Recorder can be used for many varied functions, it is not possible to discuss here each individual application in detail. However, the following illustrations and schematics are provided to give examples of some possible uses. Additional uses and information about Servo Recorders are available in the book "Electronics For Scientists," by Dr. H. V. Malmstadt and Dr. C. G. Enke.

FIVE-PIN SOCKETS FOR RAPID MODIFICATIONS

The input circuit of the Recorder is shown in Figure 6. Components and sections of the circuit are connected between the pins on three standard 5-pin plugs. Therefore, the input circuit can be easily reconnected for various functions by changing connections between the pins.

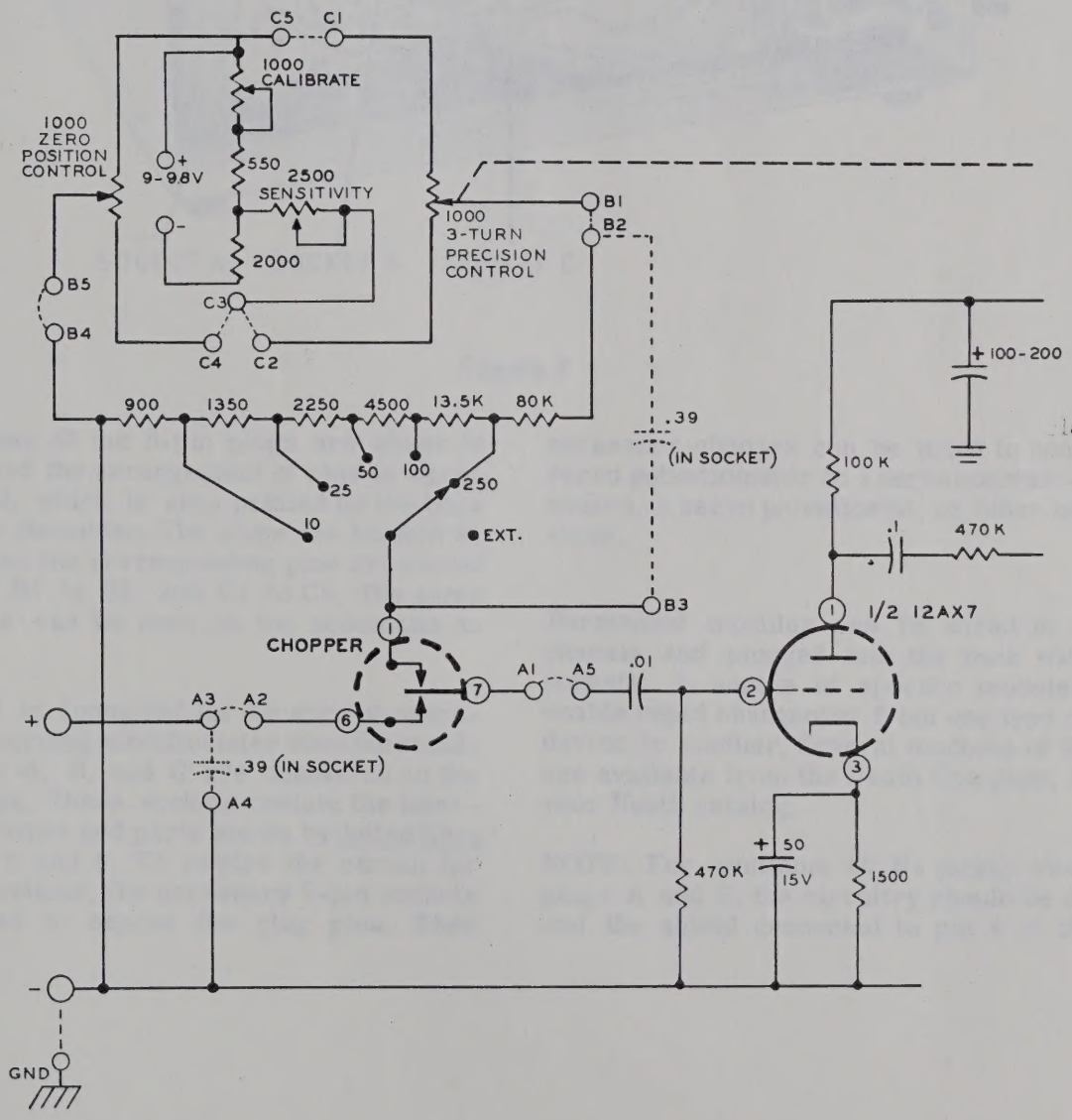
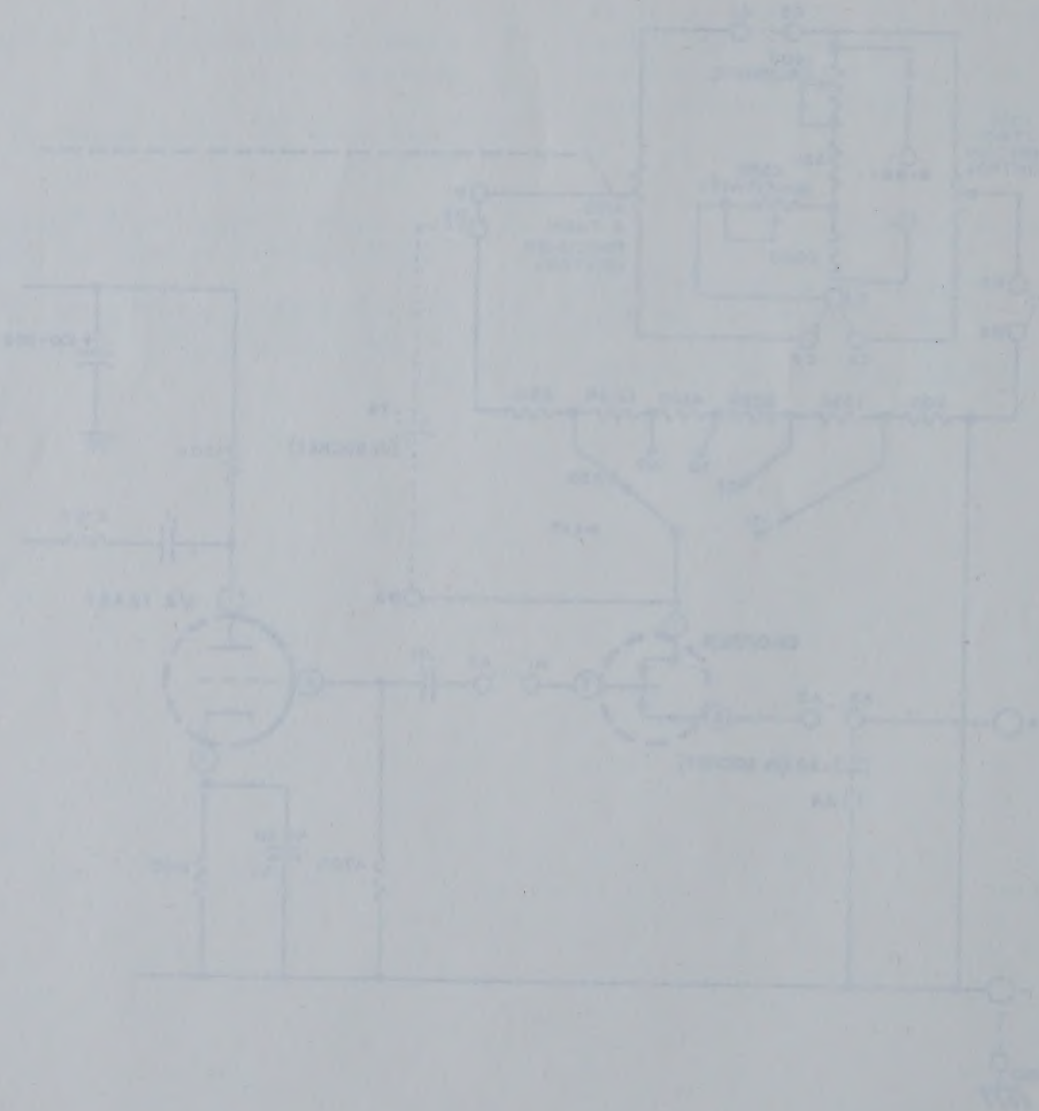


Figure 6



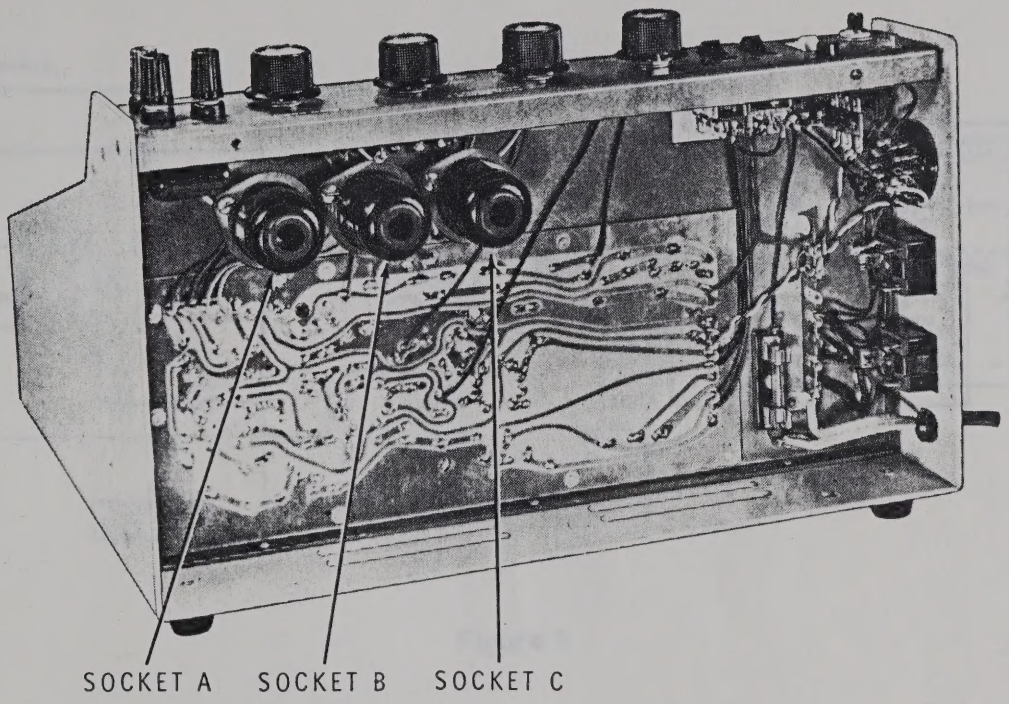


Figure 7

The locations of the 5-pin plugs are shown in Figure 7 and the arrangement of pins is shown in Figure 8, which is also printed on the back panel of the Recorder. The plugs are labeled A, B, and C, and the corresponding pins are named A1 to A5, B1 to B5, and C1 to C5. The same designations can be seen on the schematic in Figure 6.

The circuit is connected for its normal operation as a recording potentiometer when the standard sockets A, B, and C are connected to the mating plugs. These sockets contain the interconnecting wires and parts shown by dotted lines in Figures 6 and 8. To rewire the circuit for other applications, the necessary 5-pin sockets are removed to expose the plug pins. Then necessary changes can be made to convert the servo potentiometer to a servo constant-current source, a servo potentiostat, or other servo devices.

Permanent modules can be wired in suitable chassis and plugged into the back with 5-pin sockets. A series of specific modules would enable rapid changeover from one type of servo device to another. Several modules of this type are available from the Heath Company. Refer to your Heath catalog.

NOTE: For minimum 60 Hz pickup when using plugs A and B, the circuitry should be shielded and the shield connected to pin 4 of the plug.

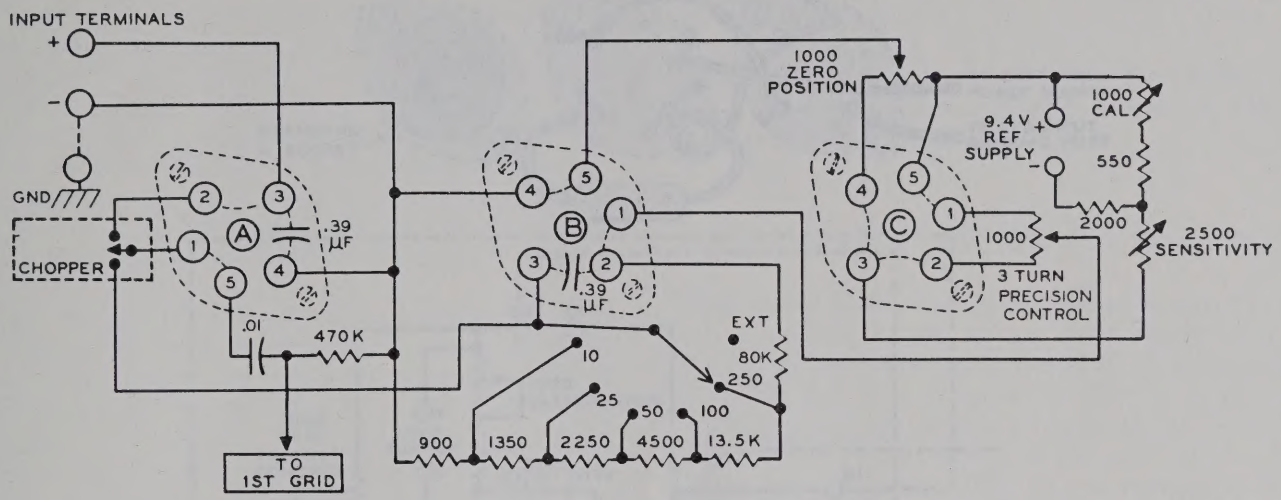
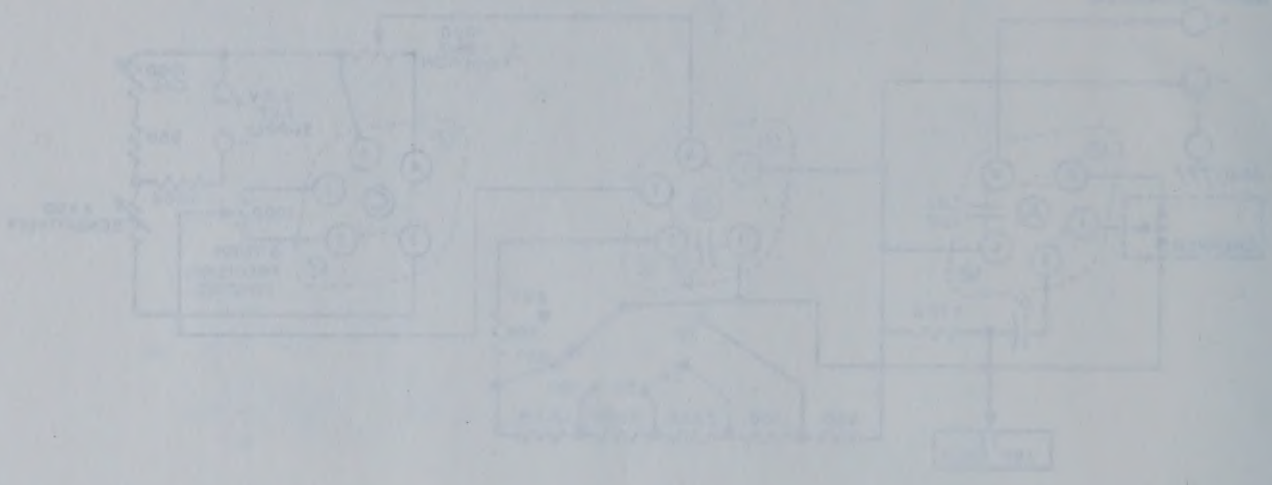

INPUT TERMINALS
+
-
GND
CHOPPER
A
.39 μF
.01
470K
TO 1ST GRID
B
.39 μF
10
25
50
100
EXT
80K
250
900
1350
2250
4500
13.5K
1000 ZERO POSITION
9.4V REF SUPPLY
+
-
1000 CAL
550
2000
2500 SENSITIVITY
C
1000
3 TURN PRECISION CONTROL

Figure 8



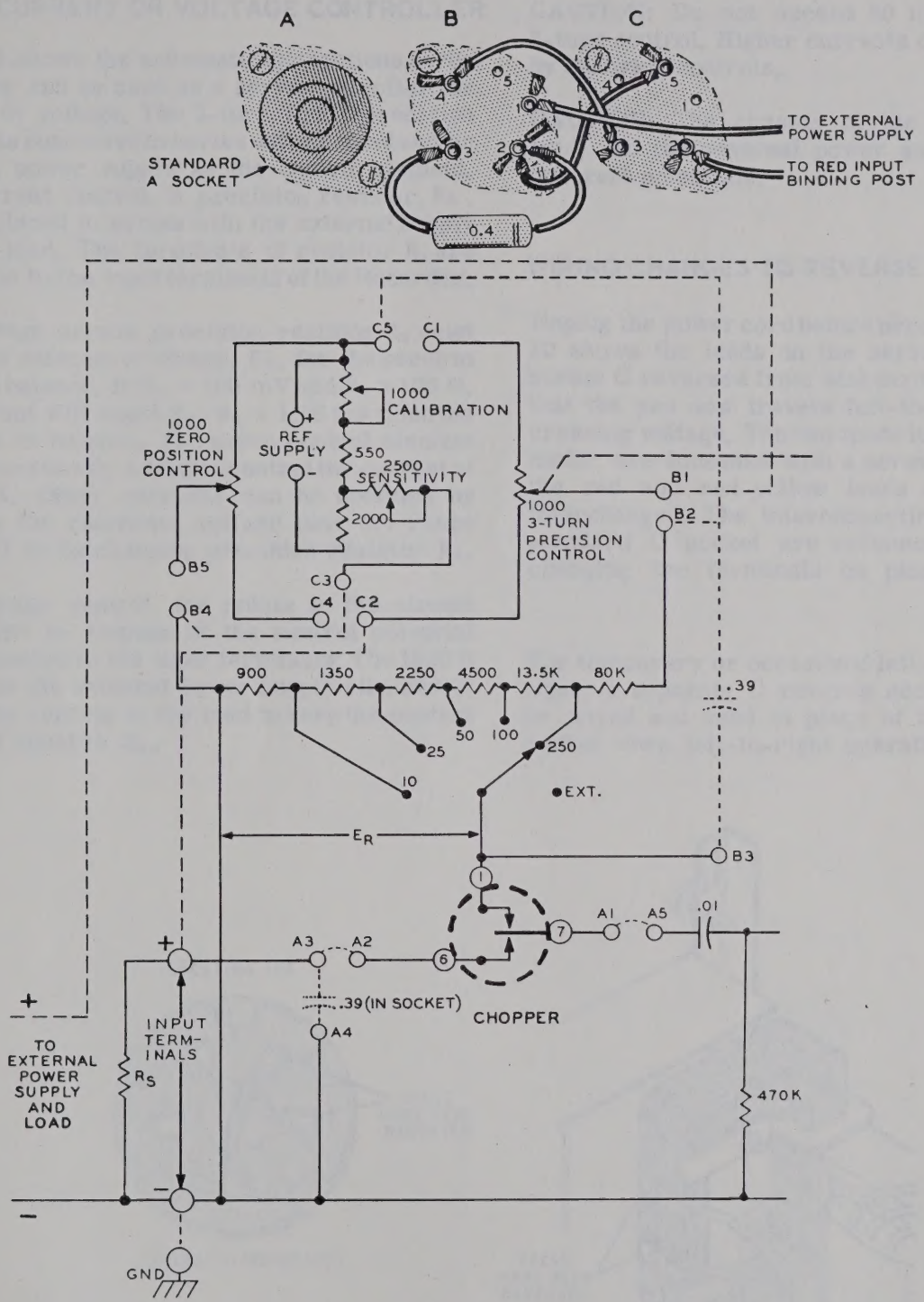
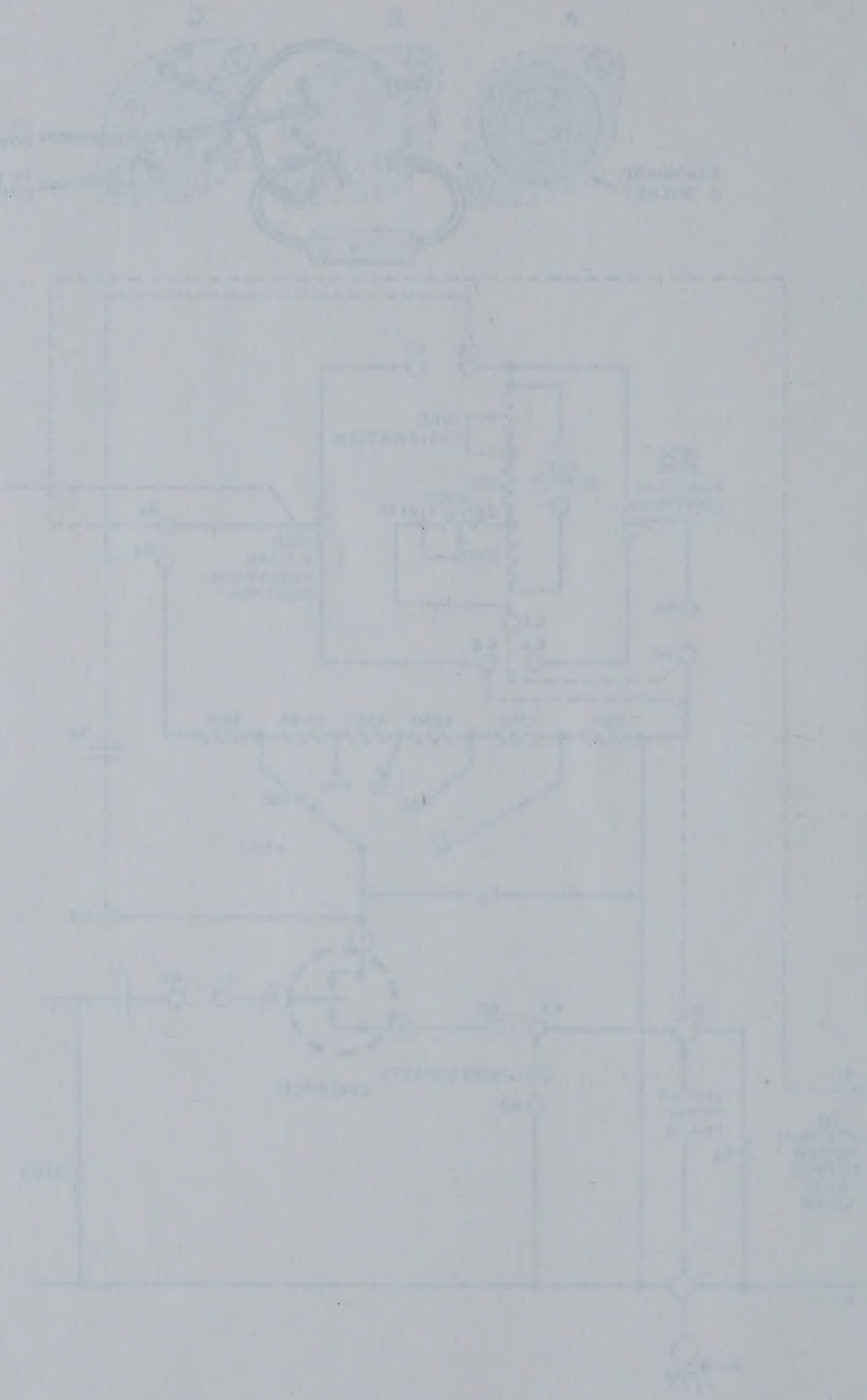

A
B
C
TO EXTERNAL POWER SUPPLY
TO RED INPUT BINDING POST
STANDARD A SOCKET
0.4
C5
C1
1000 CALIBRATION
1000 ZERO POSITION CONTROL
REF SUPPLY
550
2500 SENSITIVITY
2000
1000 3-TURN PRECISION CONTROL
B1
B2
B5
C3
C4
C2
B4
900
1350
2250
4500
13.5K
80K
.39
50
100
25
250
10
EXT.
E_R
B3
A1
A5
.01
A3
A2
.39 (IN SOCKET)
A4
CHOPPER
INPUT TERMINALS
R_S
TO EXTERNAL POWER SUPPLY AND LOAD
470K
GND

Figure 9



SERVO CURRENT OR VOLTAGE CONTROLLER

Figure 9 shows the schematic connections so the Recorder can be used as a servo controller for current or voltage. The 3-turn, 1000 Ω precision control is connected in series with the load and an external power supply as the control element. For current control, a precision resistor, R_S, is also placed in series with the external supply and the load. The terminals of resistor R_S are connected to the input terminals of the Recorder.

The voltage across precision resistor R_S must equal the reference voltage, E_R, for the servo to come to balance. If E_R = 100 mV and R_S = 100 Ω, the current will equal E_R / R_S = 1.00 mA when the servo is at balance. The servo control element will automatically adjust to control the current at 1.00 mA. Other currents can be obtained by changing the reference voltage (use the range selector) or by changing precision resistor R_S.

For voltage control, the points in the circuit which are to remain at the control potential are connected to the input terminals. The 1000 Ω control in the external power supply circuit will adjust the current to the load to keep the control potential equal to E_R.

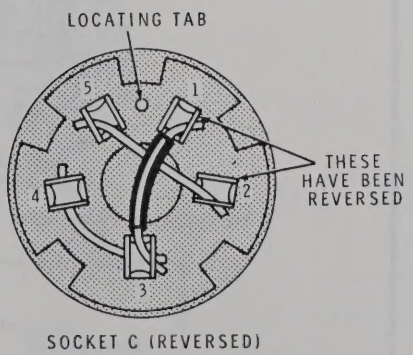
CAUTION: Do not exceed 50 mA through the 3-turn control. Higher currents can be obtained by changing controls.

CAUTION: The chassis of the Recorder, the load, and the external power supply may be at different potentials.

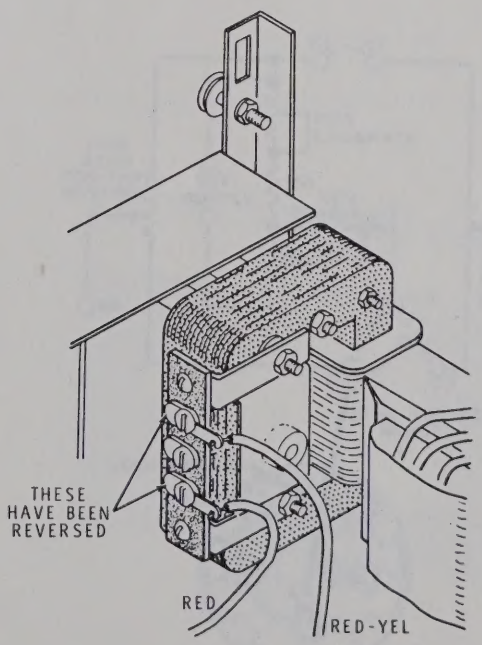
WIRING CHANGES TO REVERSE PEN TRAVEL

Unplug the power cord before proceeding. Figure 10 shows the leads on the servo motor and on socket C reversed from standard connections so that the pen now travels left-to-right with increasing voltage. The two spade lugs on the servo motor are loosened with a screwdriver so that the red and red-yellow leads can be readily interchanged. The interconnecting wires in the standard C socket are reconnected by interchanging the terminals on pins C1 and C2.

For temporary or occasional left-to-right operation, a separate C reverse socket could also be wired and used in place of the standard C socket when left-to-right operation is desired.



SOCKET C (REVERSED)



SERVO MOTOR

Figure 10

REMOTE OPERATION

The SERVO and CHART switch circuits can be connected for remote operation as described in the following paragraphs.

In order to switch the Recorder to the SERVO position remotely, it will be necessary to connect the following pins of the 11-pin socket together with an external switch or relay. Refer to the Schematic (fold-out from Page 31).

CONNECT PIN	TO PIN
2	3
5	6
9	11

To switch the Recorder to the CHART position remotely, connect pin 2 to pin 4 of the 11-pin accessory socket.

Now, to operate the Recorder, place the POWER switch in the ON position. This will supply power to the Recorder.

Several voltages are available at the Accessory socket in different SERVO and CHART switch positions. Refer to the Power Switch section under Operation on Page 5 for the voltages available at this socket.

NONLINEAR OPERATION

The Recorder can be modified to permit nonlinear recording. This is accomplished by changing the 3-turn measuring slidewire control to one having the correct electrical specifications. Controls of this type are available from various control manufacturers.

ZERO SUPPRESS

Figure 11A shows the C1 to C5 connections that are necessary for zero suppression to the left. Figure 11B shows the wiring changes for zero suppression to the right.

The amount of zero suppression and the chart span depend on the value of the zero suppress resistance. A 1000 Ω resistor would give full-scale zero suppression, and the span would be decreased to approximately one-half the normal calibrated value.

Figure 12 shows how an external voltage can be connected into the Recorder input for additional zero suppression beyond the range of the ZERO POSITION control.

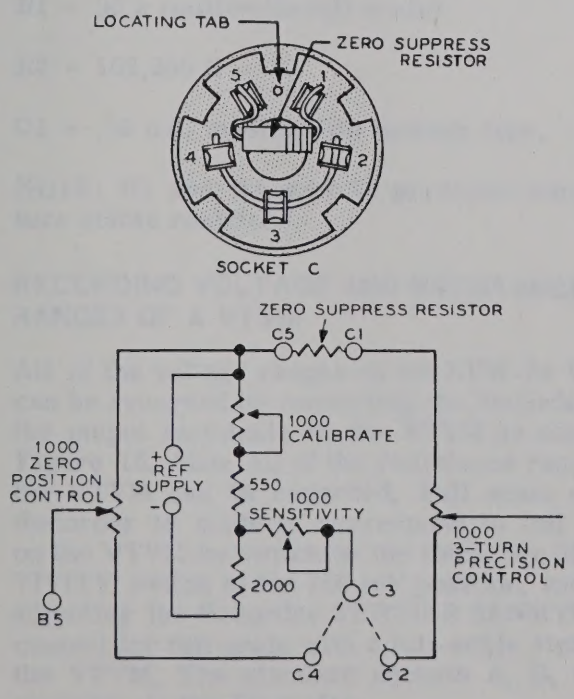


Figure 11A

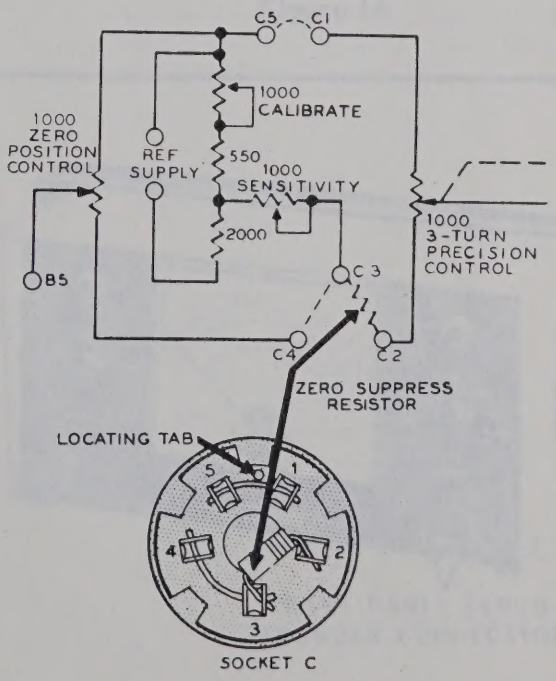
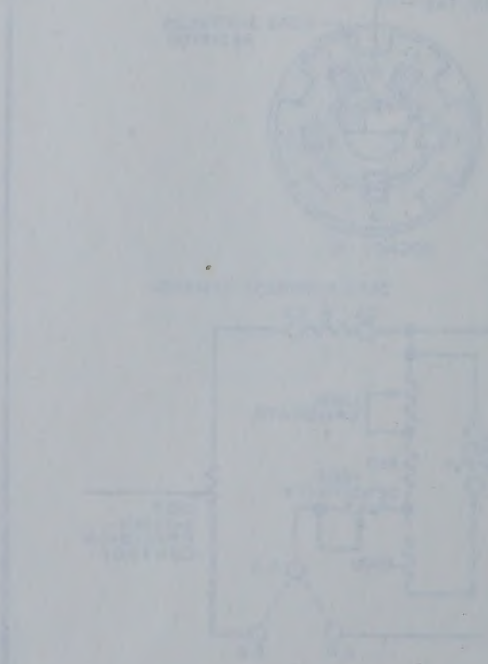


Figure 11B



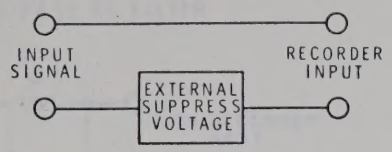


Figure 12

RECORDING HIGH VOLTAGE

Figure 13 shows a voltage divider at the input which puts only 1/1000 of the signal voltage across the chopper. Therefore, full scale on the normal 100 mV range will now be 100 volts.

EXTERNAL RANGE SOCKET

Special, fixed-calibrated, full-scale sensitivities can be obtained by using special sockets. These sockets are used in place of the standard B socket. The following formula enables you to calculate the resistor values required; the resistors are shown in Figure 14.

IMPORTANT: Use the EXTERNAL position of the range switch and turn the VERNIER SENSITIVITY to its maximum counterclockwise position when using these special sockets.

R1 = 90 x (millivolts full scale)

R2 = 102,500 Ω - R1

C1 = .39 μF, must be low leakage type.

NOTE: R1 and R2 must be precision temperature stable resistors.

RECORDING VOLTAGE AND RESISTANCE RANGES OF A VTVM

All of the voltage ranges on the EUW-24 VTVM can be recorded by connecting the Recorder into the output terminals of the VTVM as shown in Figure 15. Also, all of the resistance ranges of the VTVM can be recorded. Full scale on the Recorder is made to correspond to full scale on the VTVM by switching the Recorder SENSITIVITY switch to the 250 mV position, and then adjusting the Recorder VERNIER SENSITIVITY control for full scale with a full-scale signal on the VTVM. The standard sockets A, B, and C should be in the Recorder.

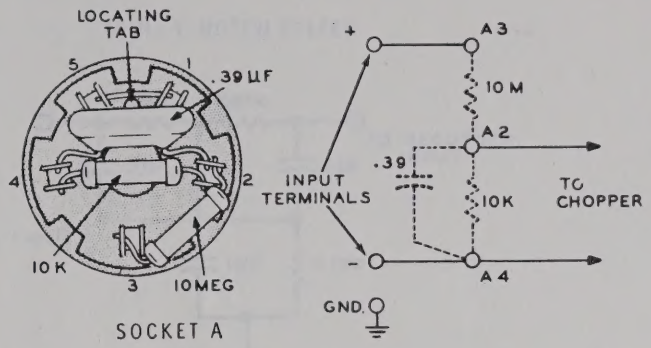


Figure 13

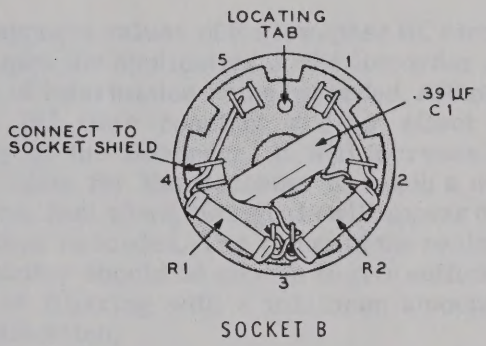


Figure 14

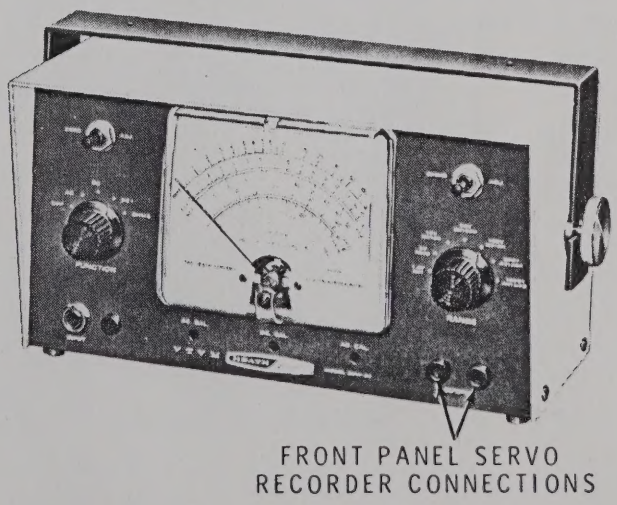
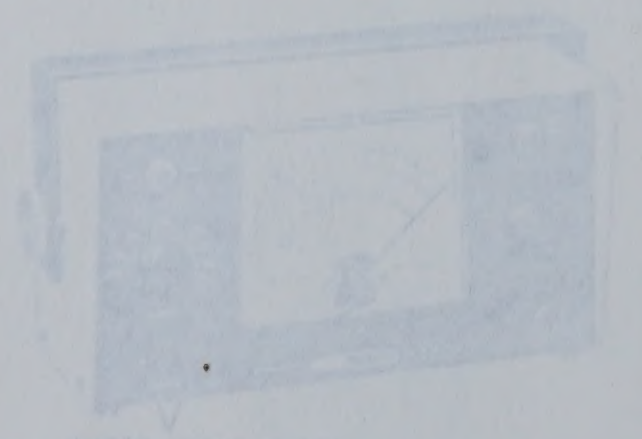


Figure 15



LOW-PASS RC FILTER

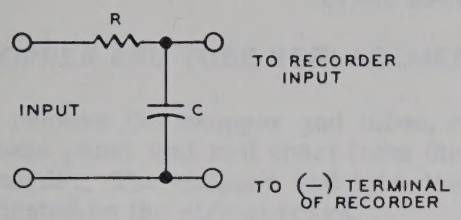


Figure 16

60 Hz T-NOTCH FILTER

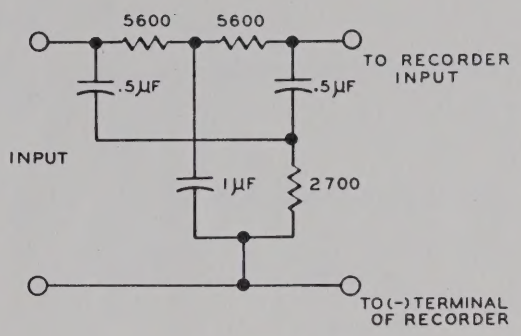


Figure 17

60 Hz FILTER

The output of some equipment will inject excessive 60 Hz noise into the Recorder Input Terminals. This will increase the dead zone and make the Recorder response sluggish. To minimize this problem, it is necessary to use a 60 Hz rejection filter at the Recorder input.

Shown in Figures 16 and 17 are two filters which can be made from discrete components and connected directly to the input terminals. The lead lengths of each component must be kept at a minimum for best results.

The component values of the low-pass RC circuit depend upon the application of the Recorder and the type of information being recorded. Although a large RC time constant will not affect the accuracy of the Recorder, it will increase the time it takes for the Recorder to reach a null. Therefore, fast changing signals will appear distorted when recorded. The values of the resistor and capacitor should be chosen to give sufficient amount of filtering with a minimum amount of signal distortion.

For information on how to convert the Recorder to an integrator or current measuring device, refer to the Journal of Chemical Education, Volume 41, Page 263, May, 1964.

MAINTENANCE

Refer to Figure 18 to identify the various parts of the Recorder.

CHOPPER AND TUBE REPLACEMENT

To remove the chopper and tubes, remove the access panel and roll chart from the top of the Recorder. The chopper and tube locations are indicated on the circuit board.

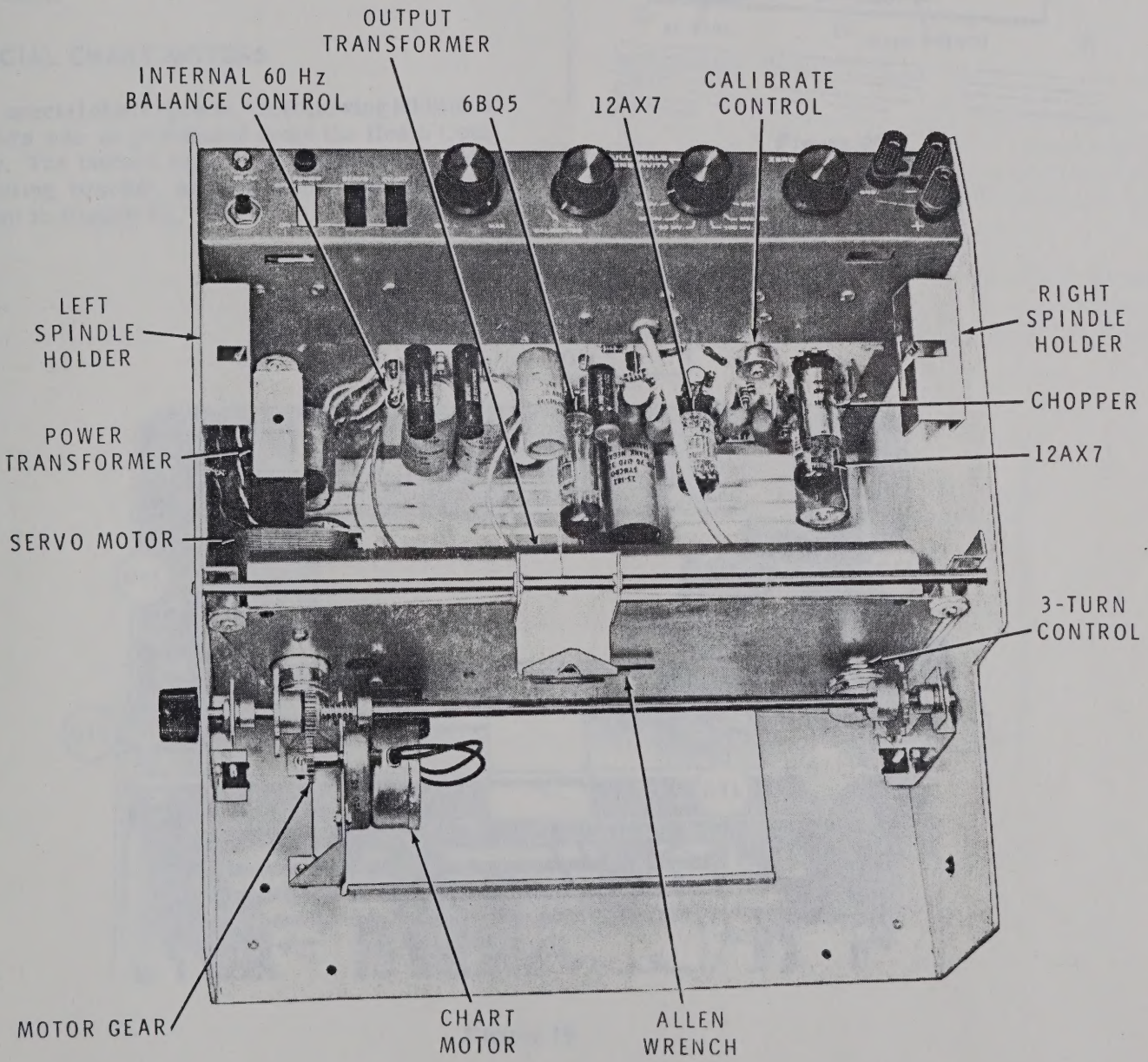


Figure 18

LUBRICATION

The Recorder should be lubricated at approximately 3-month intervals to assure proper operation. Place one drop of light machine oil at each point indicated in Figure 19. These points are accessible by removing the writing panel. This is done by removing the two screws located under the front of the Recorder. The pen carriage shaft should be wiped with an oily cloth. Do not permit any oil to touch the drive cord. This will introduce slippage and cause poor Recorder operation.

SPECIAL CHART MOTORS

For special chart speeds, the following additional motors can be purchased from the Heath Company. The motors come premounted on a motor mounting bracket. Access to the chart motor is shown in Figure 20.

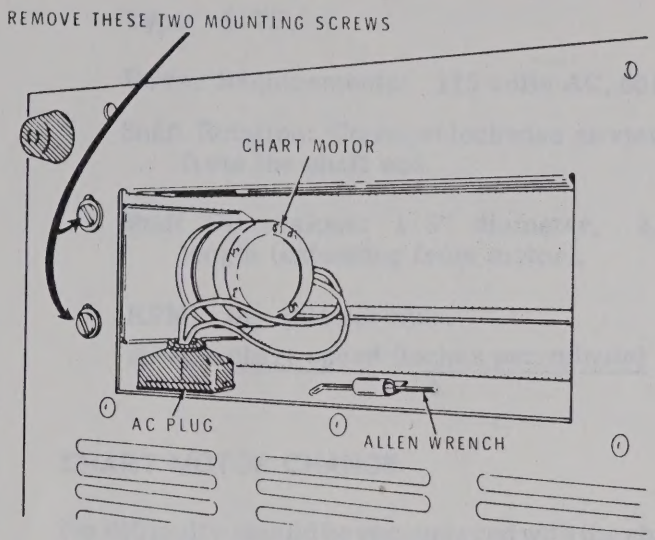


Figure 20

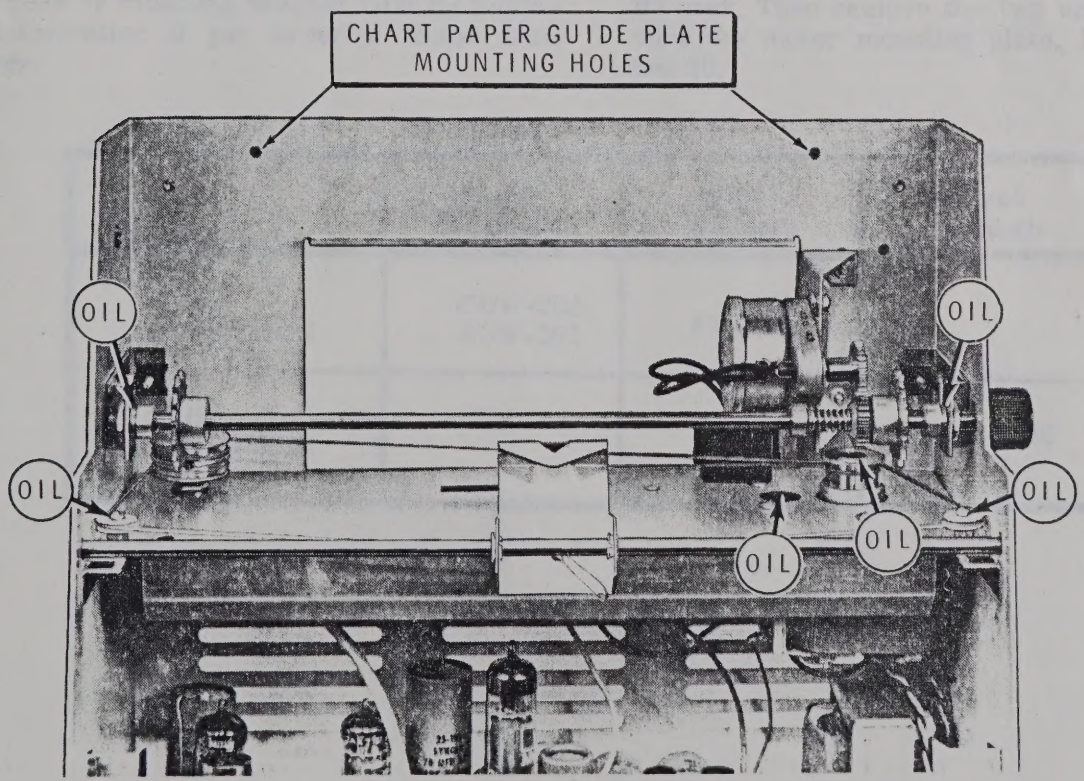


Figure 19

CHART SPEED	MOTOR MODEL NUMBER
2 inches/hour	EU-20-10
6 inches/hour	EU-20-2
12 inches/hour	EU-20-3
30 inches/hour	EU-20-4
1 inch/minute	EU-20-5
12 inches/minute	EU-20-9

NOTE: Three drive gears are supplied with each motor. The gear you will need depends upon your Recorder Model Number and the application. For example, when operating the standard EU-20B Recorder on 60 Hz line voltage, use only the 25 tooth gear (#451-57). When using the EU-20BE Recorder on 50 Hz line voltage, use only the 30 tooth gear (#451-60). For other applications, refer to the chart below.

Replacement motors for other chart speeds can be purchased from Cramer Division, Gianini Controls Corporation, Old Saybrook, Connecticut. These motors do not come equipped with a drive gear or mounting bracket. Give the following information if you order a motor from Cramer.

Type: 117P.

Power Requirements: 115 volts AC, 60 Hz.

Shaft Rotation: Counterclockwise as viewed from the shaft end.

Shaft Dimensions: 1/8" diameter, 3/8" length (extending from motor).

RPM: Use this formula.

$$\text{RPM} = \frac{\text{chart speed (inches per minute)}}{4}$$

CHART MOTOR CHANGE

No difficulty should be encountered with the chart motor. However, the motor can be interchanged with other motors of the same type to obtain different chart speeds. (See Special Chart Motors on Page 18.)

To change the chart motor, turn the Recorder on its back. Then remove the two screws that secure the motor mounting plate. Refer to Figure 20.

	451-38 26 tooth	451-57 25 tooth	451-60 30 tooth
60 Hz OPERATION	EUW-20A EUW-301	EU-20B	
50 Hz OPERATION			EU-20BE

Unplug the AC plug and remove the motor from the Recorder.

Place the new motor in the Recorder. Slide the motor towards the rear of the Recorder until the gears mesh. Check this by turning the PAPER FEED knob. Do not force the gears together; a slight amount of play is desirable. Now tighten the two mounting screws, and connect the AC plug.

3-TURN CONTROL CLEANING AND REPLACEMENT

The 3-turn control is supplied by the manufacturers completely sealed and lubricated. Should you find it necessary, the control can be disassembled and cleaned. Because the controls are obtained from more than one manufacturer, each type of control must be disassembled in a slightly different manner.

Before disassembling the control, remove it from the Recorder and examine it. NOTE: It is suggested that you place a screwdriver or similar device through the hole in the control pulley and into the hole in the drive panel. This will hold the control pulley and drive cord in position while the control is removed from the drive panel.

The back cover of the control may be held on by either screws or drive pins. These must be removed before you can remove the back cover. To remove the drive pins, insert a sharp knife blade or similar instrument under the pin heads and pry the pins out.

Carefully examine the construction of the interior of the control before completely removing the wiper assembly from the control. With a lint-free cloth, clean the control case, cap, wiperarm contact, spring, and slidewire. CAUTION: Do not scratch or mar the slidewire. A solvent should not be used for cleaning. After cleaning, reassemble the control and replace it in the Recorder.

DRIVE CORD CARE AND REPLACEMENT

To insure optimum operation of the Recorder, the drive cord must be free of oil, unfrayed, and have proper tension. Refer to Figure 21 for drive cord replacement and proceed as follows. NOTE: For proper drive cord tension adjustment, see steps 8 and 11.

1. Rotate the 3-turn control fully counterclockwise. The cord hole in the control pulley should be at the 5:00 o'clock position. If the pulley is not in this position, loosen the setscrew in the control pulley and rotate the pulley.

2. Place one end of the drive cord through the cord hole and out the front. NOTE: The pulley can be rotated to facilitate this operation, but it must be returned to the full counterclockwise position to obtain proper drive and installation. Place the cord under the washer and temporarily tighten the screw.

3. Route the drive cord over idler pulleys #1 and #2 and around the drive pulley two complete turns. Be sure the two turns go from the outside of the drive pulley to the inside.

4. Rotate the control pulley clockwise a full three turns until it hits the stop. The dial cord should now be wrapped around the control pulley, side by side, on the rear half of the pulley.

5. Route the drive cord under the control pulley, in the front half. Make one complete turn around the front portion and feed the end of the cord through the cord hole and out the front. Leave enough slack between pulleys #1 and #2 to form a 1/2" loop in the drive cord.

6. Loosen the screw and place the drive cord under the washer. Temporarily tighten the screw, securing both cords under the washer. Form a 1/2" loop with the excess cord between pulleys #1 and #2.

7. Pass the loop through the eyelet from the bottom of the pen carriage. Pull the cord through the eyelet at the top of the pen carriage and hook the loop on the hairpin spring. Do not force the cord into the hook yet; the cord must be allowed to slip through the hook until the final adjustments are made.

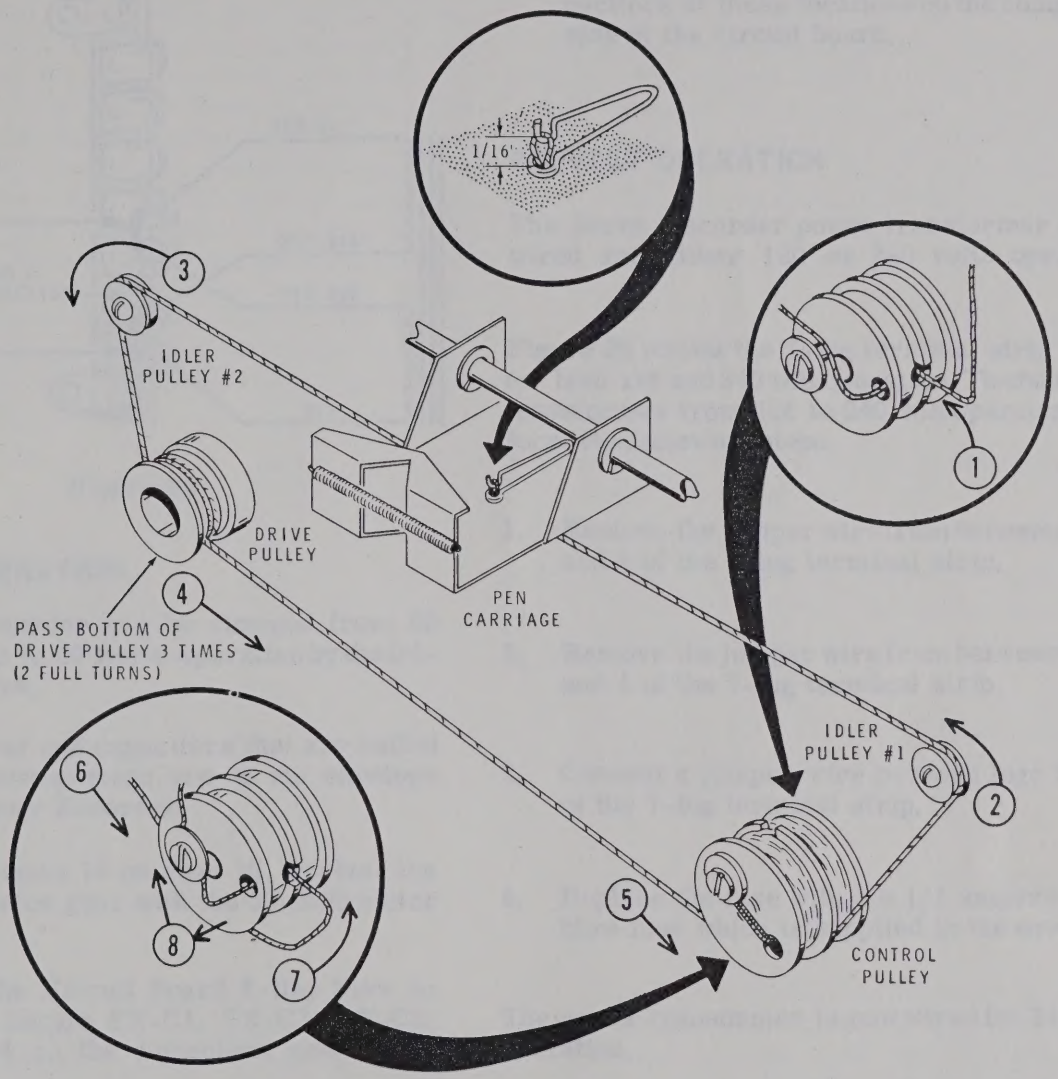


Figure 21

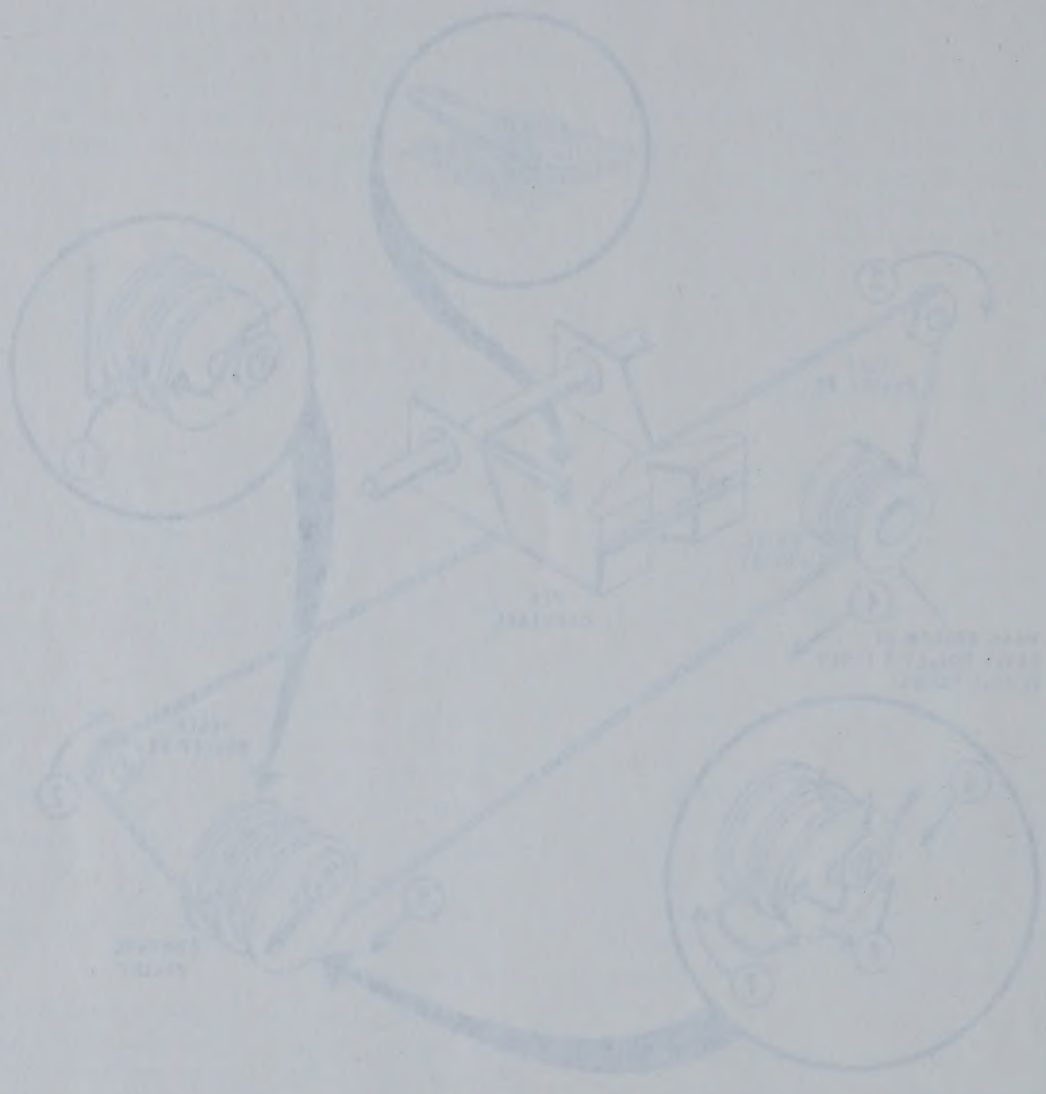
8. Loosen the screw on the control pulley and pull the drive cord until the hairpin spring is completely compressed to the eyelet. This will automatically set the drive cord tension when the cord is forced toward the bottom of the hook in the spring.

9. Turn the control to the center of its range (one and one-half turns from either end).

10. Position the pen carriage at midscale (50).

11. Pull the loop so the cord is forced toward the bottom of the hook; this will secure the cord to the hairpin spring. NOTE: There should be 1/16" clearance between the eyelet and spring. See the inset in Figure 21.

12. Rotate the servo motor pulley by hand and be sure the pen carriage hits its stops before the control hits its stop. Check to be sure the string runs properly and does not bind at any point.



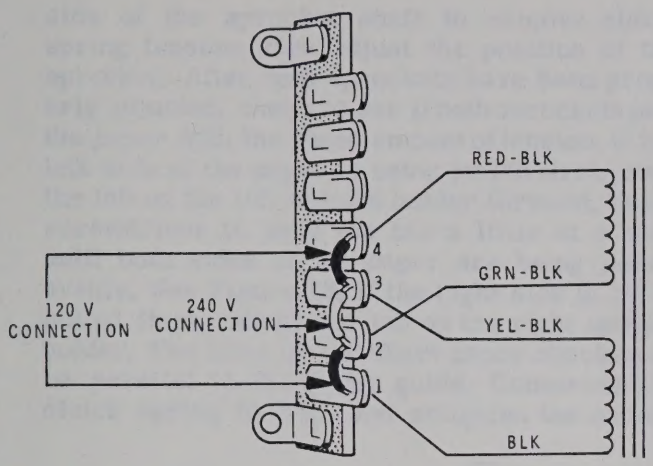


Figure 22

50 HERTZ OPERATION

The Servo Recorder can be changed from 60 Hertz operation to 50 Hertz operation by the following procedure.

NOTE: The gear and capacitors that are called for in the following steps are in the envelope supplied with your Recorder.

1. Refer to Figure 18 on Page 17. Replace the 25 tooth motor gear with the 30 tooth motor gear.

2. Refer to the Circuit Board X-Ray View on Page 30. Locate EX-C1, EX-C2, EX-C3, and EX-C4 on the component side of the circuit board. Install the four .005 μF capacitors at these locations on the component side of the circuit board.

240 VOLT OPERATION

The Servo Recorder power transformer can be wired for either 120 or 240 volts operation.

Figure 22 shows the 7-lug terminal strip wiring for both 120 and 240 volt operation. To change the transformer from 120 to 240 volt operation perform the following steps.

1. Remove the jumper wire from between lugs 1 and 2 of the 7-lug terminal strip.

2. Remove the jumper wire from between lugs 3 and 4 of the 7-lug terminal strip.

3. Connect a jumper wire between lugs 2 and 3 of the 7-lug terminal strip.

4. Replace the fuse with the 1/2 ampere slow-blow fuse which is supplied in the envelope.

The power transormer is now wired for 240 volt operation.

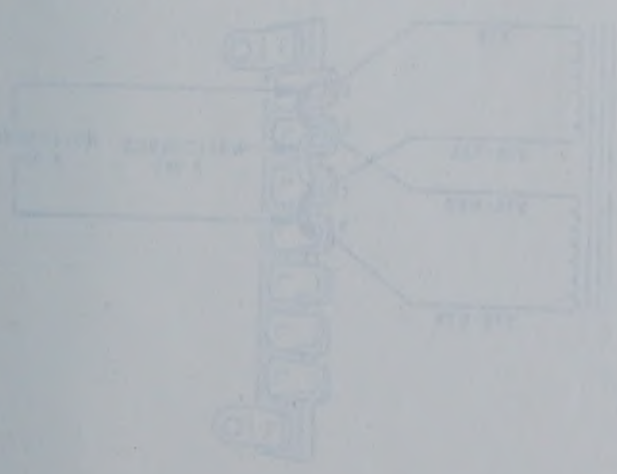
ADJUSTMENTS

The following adjustments are made at the factory before the unit is shipped. However, if difficulty is encountered or maintenance work performed, it may be necessary for you to readjust some of these points. An allen wrench is furnished to make these adjustments. (See Figure 20.) The following procedures should be used.

PAPER AND PEN ALIGNMENT

Be sure the paper feeds through the Recorder evenly. If it does not, it will be necessary to adjust the spindle holders and paper drive sprockets. The sprockets should be set in the center of the slot in the paper guide, and the teeth should be in line with each other. If they are not, loosen the setscrews in the right-hand sprocket and reset the sprocket on the shaft. Use the paper guide edge and the chart paper grid lines as a guide when aligning the sprocket teeth.

If the left-hand sprocket is not centered in the paper guide plate, loosen the collar on the left



side of the sprocket shaft to remove clutch spring tension; then adjust the position of the sprocket. After both sprockets have been properly adjusted, check to see if both sprockets pull the paper with the same amount of tension. If the left side of the paper is being pulled first, bend the tab on the left spindle holder forward. Use a screwdriver to bend the tab a little at a time until both sides of the paper are being pulled evenly. See Figure 23. If the right side is being pulled first, adjust the tab on the right spindle holder. The lines on the chart paper should now be parallel to the paper guide. Compress the clutch spring to 3/4" and retighten the collar.

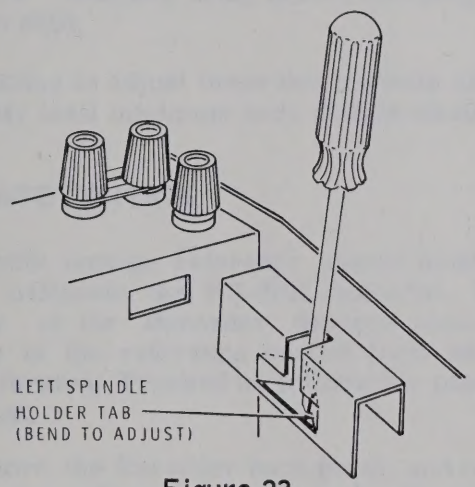


Figure 23

After chart paper alignment has been accomplished, start the paper through the Recorder. Stop the Recorder and move the pen across the chart paper. The pen should follow parallel to the chart paper grid lines. If it does not, loosen the screw in the left end of the pen carriage shaft and move the shaft in the proper direction until the pen follows the grid lines on the chart paper. Retighten the screw.

SPROCKET HEIGHT ADJUSTMENT

It is important that the sprockets be high enough to mesh properly in the sides of the chart paper. This adjustment can be made by loosening the drive shaft mounting bracket screws, and turning the sprocket height adjustment screws. See Figures 1A and 1B (fold-out from Page 4). Retighten the mounting bracket screws. Proper mesh is obtained when the sprocket teeth just fill the holes in the paper.

INTERNAL 60 Hz BALANCE CONTROL

The zero position (null point) of the pen carriage should not change when you change the SENSITIVITY switch from one range to another. If the zero position shifts, it is an indication that the INTERNAL 60 Hz BALANCE control is improperly adjusted. To adjust this control, proceed as follows.

1. Turn the Recorder on and allow it to warm up for about 10 minutes.

2. Remove the access panel and chart paper from the Recorder.

3. Short the input by connecting a short wire from the positive (+) to the negative (-) Input Terminal.

4. Place the SENSITIVITY switch in the 25 mV position and increase the damping until the pen carriage stops oscillating.

5. Adjust the NULL control for minimum glow of the 60~ Indicator lamp.

6. Change the SENSITIVITY switch position alternately from 25 mV to 10 mV. Observe the amount of zero shift (the distance the pen carriage moves when the switch position is changed) and the direction the pen carriage travels.

CAUTION: High voltage is present in the area around the BALANCE control. Do not touch or short across any leads or components. NOTE: The eraser end of a lead pencil may be used to move the wiper arm in the following step. However, it is suggested that a piece of tape be used to cover the metal portion of the lead pencil.

7. Leave the SENSITIVITY switch in the 25 mV position. With an insulated tool, carefully move the wiper arm of the INTERNAL 60 Hz BALANCE control approximately 1/16" in either direction.

8. Readjust the NULL control for minimum glow of the 60~ Indicator lamp. Then repeat step six and notice the change in the amount and direction of the zero shift. If the zero shift decreased, continue to move the wiper on the INTERNAL 60~ BALANCE control in the same direction. If the zero shift increased or changed direction after the first adjustment, move the wiper on the INTERNAL 60~ BALANCE control in the opposite direction. Always move the wiper a little at a time. After each INTERNAL 60 Hz BALANCE control adjustment, readjust the NULL control for minimum glow of the 60~ Indicator lamp before checking the zero shift.

9. Continue to adjust these two controls alternately until minimum zero shift is obtained.

CALIBRATE CONTROL

An accurate voltage reference source must be used to calibrate the EU-20B Recorder. The accuracy of the Recorder depends upon the accuracy of the reference source from which it is calibrated. Proceed as follows for proper calibration.

1. Remove the Recorder back panel, and connect the reference source to the Recorder input terminals.

2. Turn the Recorder on and set the SENSITIVITY switch to the 100 mV position, or that range which you will use most. Make sure the VERNIER SENSITIVITY Control is at the maximum counterclockwise position.

3. Place the SERVO switch in the ON position.

4. Set the reference source for zero output voltage and adjust the ZERO POSITION control until the pen is at the zero position on the chart paper.

5. Adjust the NULL control for minimum glow of the 60 ~ Indicator lamp.

6. Set the reference source for 100 mV output voltage.

7. Adjust the CALIBRATE control (See Figure 1B) for full scale pin travel. The pen should be resting on the 100 line on the chart paper.

ZENER CURRENT CALIBRATE

The zener current will not normally require calibration. In the event that it should require adjustment, proceed to the following steps.

1. Remove the back panel.

2. Remove the jumper wire between R46 and D5 on the circuit board.

3. Connect a current meter, of at least 3% accuracy, between R46 and R50. The polarity is indicated on the circuit board screen.

4. Turn the recorder on and allow it to warm up for about 10 minutes.

5. Adjust R 50 until a current flow of 10 mA is indicated on the meter.

6. Turn the recorder off and disconnect the meter.

7. Reinstall the jumper wire you removed.

The Recorder is now properly calibrated. Replace the back panel on the Recorder.

IN CASE OF DIFFICULTY

This section of the Manual will help you isolate and repair most of the problems that might develop in your Chart Recorder. It would be very difficult to describe each possible problem. However, a Troubleshooting Chart is supplied with a list of Symptoms and Possible Causes. Although the Possible Cause section may not always point out the faulty component, it will get you on the right track for further analysis. This will help you eliminate the functions that operate normally and lead you to the area of the problem. Once the problem has been localized, you can use standard troubleshooting techniques to determine the component that is causing the problem.

NOTE: Should you prefer to have the Chart Recorder repaired at the factory, or if you need additional information before you proceed, refer to the Service Information section inside the front cover of the Manual.

Troubleshooting Chart

SYMPTOM	POSSIBLE CAUSE	REMEDY
Pen will not overshoot with Damping control in full counterclockwise position. Input short-circuited and Recorder on 250 mV range.	1. Defective tube. 2. Poor chopper action.	1. Replace tube. 2. Replace chopper.
Nonuniform pen speed through full range of travel.	1. Pen carriage binding on shaft. 2. Drive cord tension insufficient. 3. Bind in mechanical system.	1. Clean shaft. 2. Adjust tension. 3. Eliminate bind by cleaning, adjusting and lubricating.
Pen travels faster in one direction than in other.	1. Balancing signal has non-symmetrical waveform due to poor chopper. 2. Drive cord tension insufficient. 3. Improper 60~ Null adjustment.	1. Replace chopper. 2. Adjust tension. 3. Reset the Null control.
Poor sensitivity, large dead zone.	1. Stray AC pickup. 2. Excessive 60 Hz in signal source. 3. Drive cord tension insufficient or excessive. 4. Bind in mechanical system. 5. Low amplifier gain. 6. Excessive source resistance. 7. Servo motor dirty.	1. Check for improper grounding. AC on input terminals. 2. Eliminate 60 Hz noise in signal source or try to cancel out with Null control. 3. Adjust the tension. Refer to Page 20 for information. 4. Eliminate bind by cleaning, adjusting, and lubricating. 5. Check tubes for gain and noise. 6. Be sure source resistance is less than 50 kΩ. 7. Remove motor, clean gears, and lubricate shafts.
Calibration drifts, instrument will not calibrate.	1. Defective reference supply.	1. Check zener diodes and precision resistors.
Pen moves to extreme position of pen travel and stays there.	1. Open circuit in input system. 2. Chopper malfunction. 3. Reversing of pen travel not performed properly.	1. Check external connections. 2. Replace chopper. 3. Check for reversed motor leads or reversed C socket leads.
Pen oscillates at any position of Damping control.	1. Loose motor pulley or 3-turn control pulley.	1. Tighten pulleys.
Repeated pen "jitter" at same point on chart.	1. Dirty 3-turn control.	1. Clean 3-turn control.
Zero position shifts when Sensitivity switch is changed.	1. Internal 60 Hz Balance control improperly adjusted.	1. Adjust Internal 60 Hz Balance control. See Adjustment section of Manual.

Troubleshooting Chart

SYMPTOM	POSSIBLE CAUSE	REMEDY
Fan will not operate with temperature control in full counterclockwise position, light switch on and thermostat on any step.	1. Defective motor. 2. Poor ceramic action.	1. Replace fan. 2. Replace ceramic.
Noisy fan or noise in fan bearings.	1. Fan bearings binding or worn. 2. Fan or motor bearings worn. 3. Fan blade loose. 4. Fan is mechanical system.	1. Clean, oil, replace fan. 2. Replace fan. 3. Tighten hub or clamping screw.
Fan operates but does not change speed.	1. Selector switch has no continuity. 2. Capacitor has no continuity. 3. Open in motor. 4. Improper fit- Shaft adjustment.	1. Replace switch. 2. Replace capacitor. 3. Repair or replace motor.
Fan operates, noisy and wobbly.	1. Fan is bent. 2. Fan is out of balance. 3. Motor is worn. 4. Fan is mechanical system. 5. Fan is loose on shaft. 6. Fan is out of alignment.	1. Replace fan. 2. Balance fan. 3. Replace motor. 4. Tighten or adjust fan.
Fan operates, but not at full speed.	1. Selector switch is defective.	1. Check selector switch and replace if necessary.
Fan operates at wrong speed or in wrong direction.	1. Improper fit- Shaft adjustment. 2. Capacitor has no continuity. 3. Motor is worn.	1. Adjust fan. 2. Replace capacitor. 3. Replace motor.
Fan operates, but not at full speed.	1. Improper fit- Shaft adjustment. 2. Motor is worn.	1. Adjust fan. 2. Replace motor.
Fan operates, but not at full speed.	1. Improper fit- Shaft adjustment. 2. Motor is worn.	1. Adjust fan. 2. Replace motor.

CIRCUIT DESCRIPTION

Follow the circuit on the main Schematic (fold-out from Page 31) and Block Diagram while reading the following Circuit Description. This description is divided into sections that match the individual circuits of the Recorder. Simplified Schematic Diagrams are provided for each section.

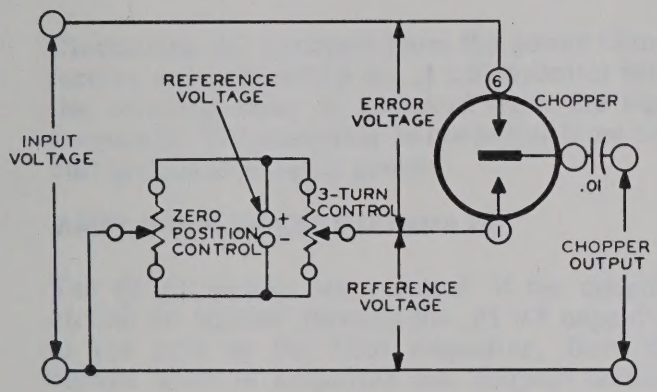


Figure 24

SELF-BALANCING POTENTIOMETER CIRCUIT (Figure 24)

The Zero Position control sets the marking pen at the desired point on the chart paper with zero input voltage (input shorted). Under these conditions the measuring slidewire is automatically adjusted by the servo motor to produce a zero reference voltage. This results in zero AC output voltage from the chopper, which is the balanced condition.

The actual reference voltage is made variable by a voltage divider network consisting of the Range switch, Vernier controls, and precision resistors. The voltage divider circuit is not shown in the simplified schematic.

When a DC voltage is applied to the input terminals, it is compared with the reference voltage by the chopper, which switches back and forth between the two voltages. The difference between these two voltages, called the error voltage, appears as a DC voltage between the two inputs of the chopper and as an AC voltage at the output of the chopper. The error voltage or signal, is then applied through amplifier circuits to the servo motor.

The signal causes the servo motor to turn in the proper direction to adjust the measuring slidewire control the proper amount to cancel the error voltage. When the servo motor turns, it moves the marking pen; thus, the movement is recorded on the chart paper. At balance, the reference voltage is equal to the input voltage; therefore, the marking on the chart paper directly indicates the amount of input signal.

The chopper, in comparing the reference voltage to the DC input voltage, produces the AC voltage required to operate the servo motor. The drive coil of the chopper is connected to a 6.3 volt, 60 Hz AC voltage; this causes the contacts to switch at a 60 Hz rate.

For example, during the time that the movable contact is at contact 6 (see Figure 24), DC input voltage X (see Figure 25) is applied to the .01 μF capacitor in the output of the chopper circuit. When the movable contact of the chopper is at contact 1, reference voltage Y is applied to the .01 μF capacitor. This procedure, which occurs at a 60 Hz rate, produces a 60 Hz square wave signal.

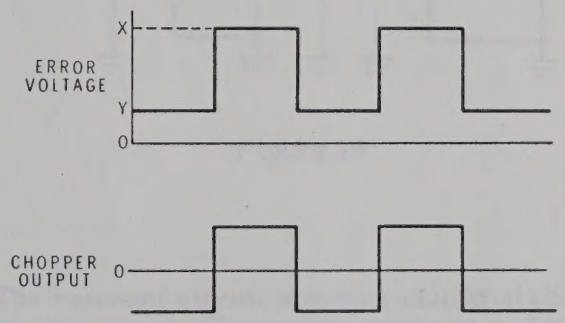
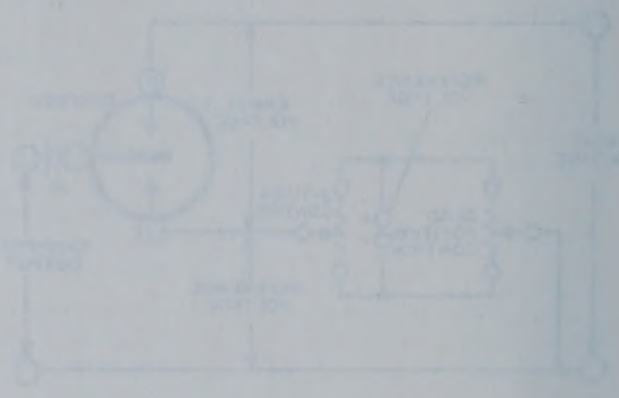
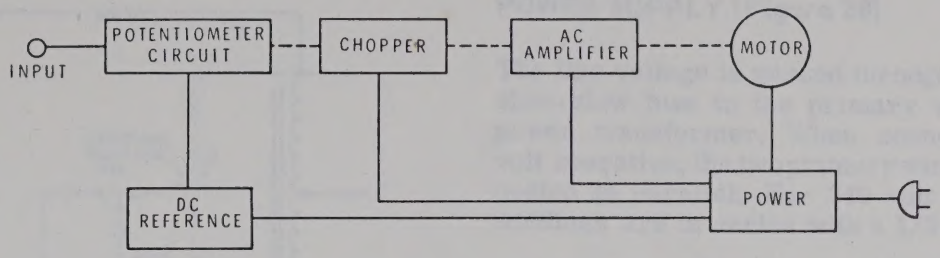


Figure 25

The square wave signal passes through the .01 μF capacitor, which removes the DC component, leaving an alternating signal that varies above and below the zero reference level. The polarity of the DC error voltage to the chopper determines the phase of the square wave output of the chopper.





BLOCK DIAGRAM

Circulating AC currents from the power transformer are reduced by the .4 μF capacitor when the shorting strap is removed from the input terminals. The capacitor is connected from circuit ground to chassis ground.

AMPLIFIER CIRCUIT (Figure 26)

The 60 Hz square wave output of the chopper circuit is applied through the .01 μF capacitor to the grid of the first amplifier. Here the square wave is amplified and coupled through the .1 μF coupling capacitor and 470 kΩ series resistor to the grid of the second amplifier stage.

Wave shaping circuits are located in the grid circuits of the second, third, and fourth voltage amplifiers, and in the power amplifier. These circuits consist of a .01 μF bypass capacitor and the 470 kΩ series resistor. When the square wave signal passes through the amplifiers and shaping circuits, the corners are rounded until the square wave becomes a much amplified sine wave.

Each wave shaping circuit also shifts the phase of the signal by approximately 22 degrees. When the signal reaches the power amplifier circuit, it is shifted a total of 90 degrees. This is the correct phase for maximum torque of the servo motor.

In the power amplifier, the signal is amplified and applied by means of a 60 Hz resonant circuit to the control winding of the servo motor.

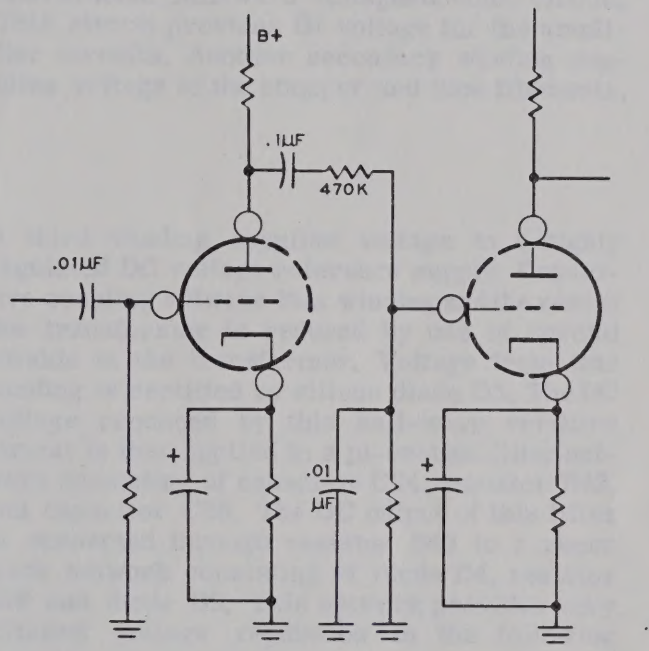
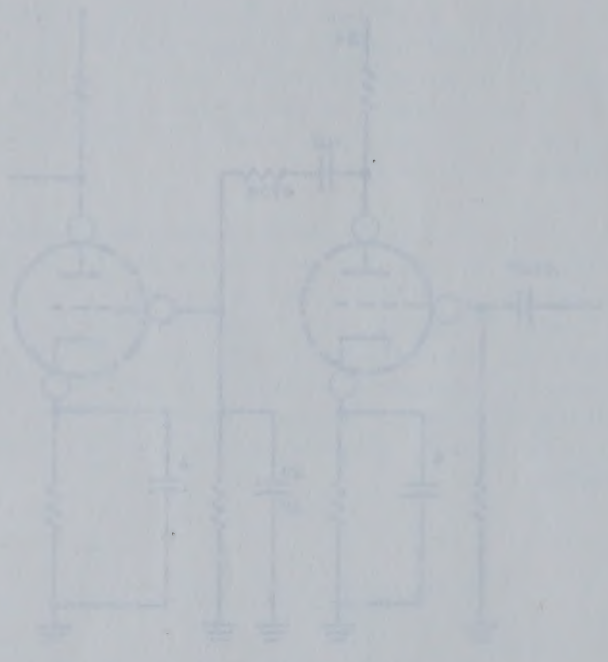


Figure 26

The resonant circuit provides additional shaping of the signal. The servo motor is a 2-phase motor, with line voltage applied to one winding. The direction in which the servo motor rotates depends on the phase of the current of the applied sine wave from the amplifier, with respect to the phase of the line voltage current.



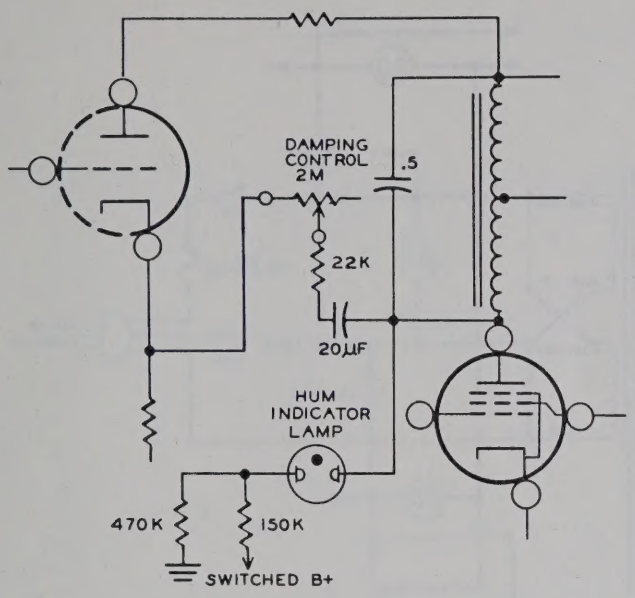


Figure 27

IMPEDANCE-REDUCTION DAMPING CIRCUIT (Figure 27)

A small amount of the signal at the plate of the power amplifier circuit is coupled by the 20 μF capacitor, the 22 kΩ resistor, and the Damping control to the cathode of the preceding voltage amplifier. This signal is 180 degrees out-of-phase with the incoming signal; thus it acts as negative feedback. This negative feedback lowers the impedance of the output stage, giving the power amplifier greater control over the servo motor. This greater control reduces the amount of overshoot as the potentiometer circuit reaches zero. The negative feedback also produces a reduction of gain in the amplifier.

The 60 ~ neon Indicator lamp is biased by a voltage divider network to a point where a small signal at the plate of the power amplifier will cause it to glow. It is therefore normal for the hum indicator to glow while the servo is seeking a null.

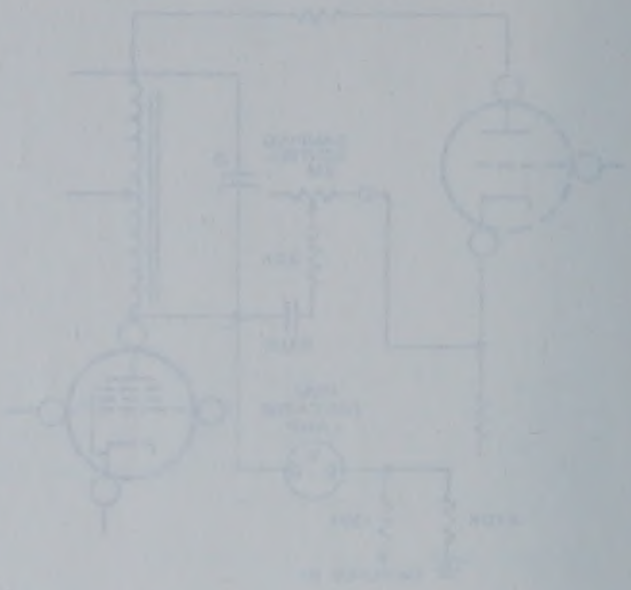
POWER SUPPLY (Figure 28)

The line voltage is passed through a one ampere slow-blow fuse to the primary windings of the power transformer. When connected for 120 volt operation, the two primary windings are connected in parallel. For 240 volt operation, the windings are in series with a 1/2-ampere fuse.

One secondary winding supplies voltage to a conventional full-wave voltage-doubler circuit. This circuit provides B+ voltage for the amplifier circuits. Another secondary winding supplies voltage to the chopper and tube filaments.

A third winding supplies voltage to a highly regulated DC voltage reference supply. Capacitive coupling between this winding and the rest of the transformer is reduced by use of special shields in the transformer. Voltage from this winding is rectified by silicon diode D3. The DC voltage produced by this half-wave rectifier circuit is then applied to a pi-section filter network consisting of capacitor C24, resistor R42, and capacitor C25. The DC output of this filter is connected through resistor R43 to a zener diode network consisting of diode D4, resistor R46 and diode D5. This network provides very efficient voltage regulation in the following manner.

Zener diodes D4 and D5 are reverse-biased semiconductor junction devices that operate as constant voltage regulators. Their operation is similar to that of gas-filled voltage regulator (VR) tubes. The regulation point of zener diode D4 is 20 volts nominal with a tolerance of 10 percent, which maintains the voltage at the level required at this circuit point. D5 is a temperature compensated zener diode with a regulation point of 9.4 volts nominal, and an operating tolerance which results in an actual regulated output between 9 volts and 9.8 volts DC.



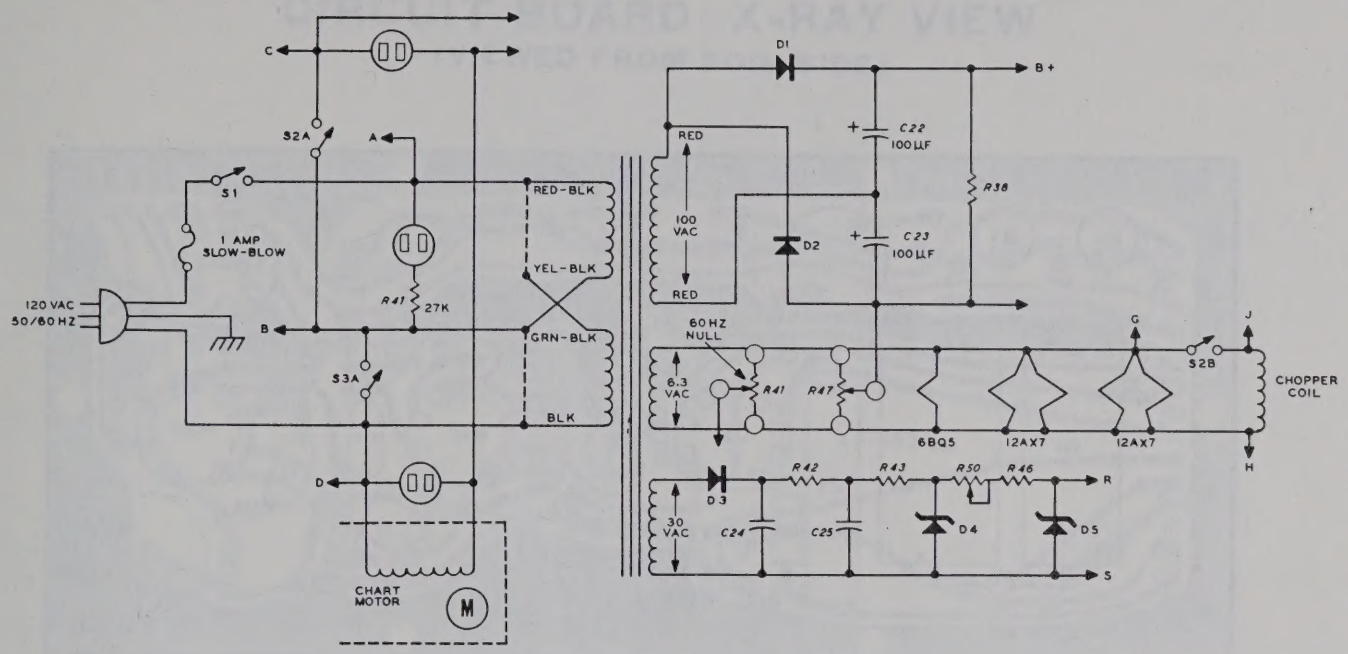


Figure 28

Resistor R50, which is connected between zener diode D4 and D5, is factory calibrated. The total current flow through R46 and R50 is limited to 14.1 mA. The value of the load is such that the load current is 4.1 mA. The remaining 10 mA, flowing through zener diode D5, is the current at which this diode is most stable with respect to the temperature.

The total load across this reference supply consists of the Calibrate control, Sensitivity control and slidewire system, and supply resistors R43 and R46. With this series-parallel circuit, the total load current is the optimum 4.1 mA when the Recorder is correctly calibrated and the Sensitivity control is at its maximum counterclockwise position.

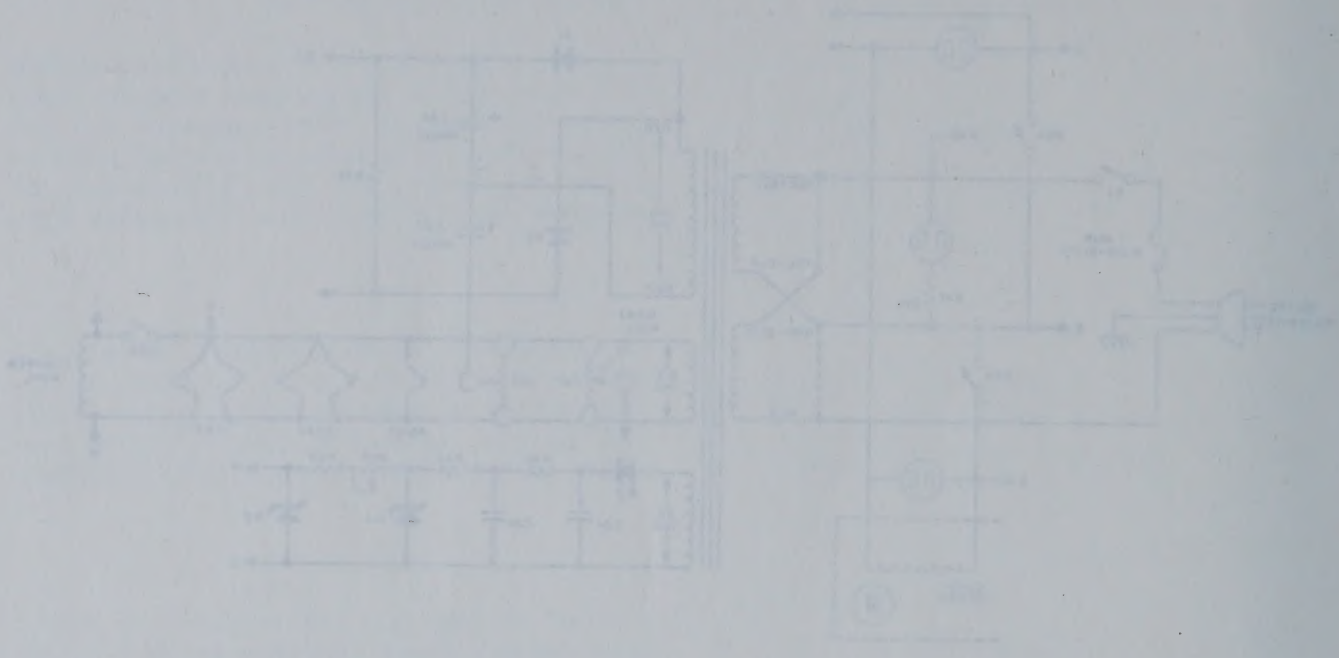
Wide range 60 ~ adjustment is provided by the Null control, which applies a 60 Hz cancelling voltage of the correct amplitude and phase to the cathode of the fourth voltage amplifier. This control will cancel most 60 Hz signals that originate at the input terminals and the external source being measured or recorded.

Additional 60 Hz cancellation is provided by the Internal 60 Hz Balance control. This control balances out any 60 Hz noise which is generated within the Recorder.

MECHANICAL

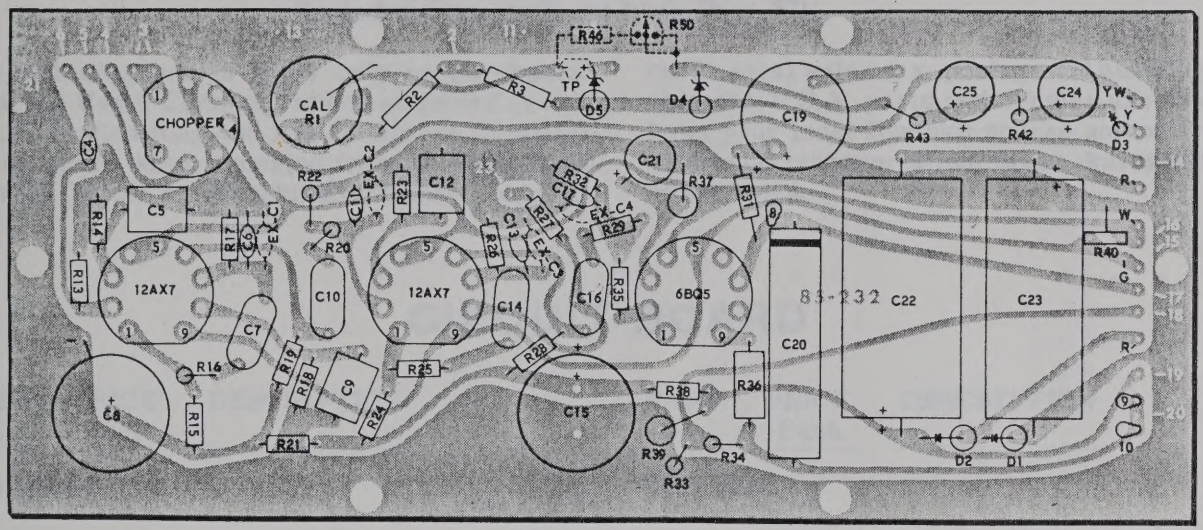
The servo motor is mechanically coupled by the drive cord to the measuring slidewire control. The drive cord also is attached to the marking pen carriage. As the servo motor rotates to move the measuring slidewire control, the pen carriage moves, and the amount of movement is recorded on the chart paper.

The chart paper is fed through the Recorder by two motor driven sprockets that mesh with the perforations in the edges of the chart paper. The motor speed and gearing of the sprockets determine the chart speed.



CIRCUIT BOARD X-RAY VIEW

(VIEWED FROM FOIL SIDE)



REPLACEMENT PARTS LIST

NOTE: The numbers in parentheses are keyed to the numbers on the Parts Pictorial and Exploded View (fold-out from Page 32).

The following prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from an authorized Service Center or Heathkit Electronic Center to cover local sales tax, postage and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.

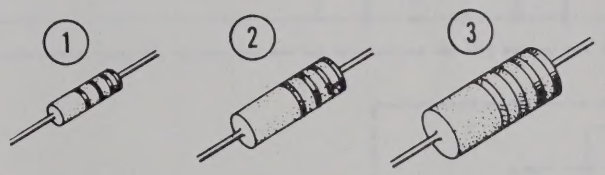
CIRCUIT BOARD

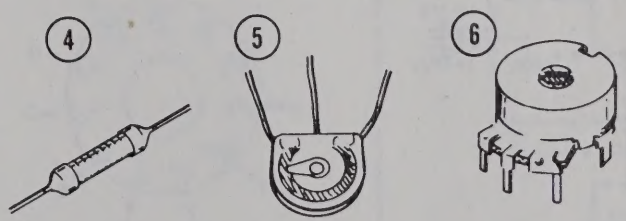
PART No.	PRICE Each	DESCRIPTION
RESISTORS		
1/2 Watt		
(1) 1-4	.10	330 Ω (orange-orange-brown)
1-6	.10	470 Ω (yellow-violet-brown)
1-11	.10	1500 Ω (brown-green-red)
1-22	.10	22 kΩ (red-red-orange)
1-25	.10	47 kΩ (yellow-violet-orange)
1-26	.10	100 kΩ (brown-black-yellow)
1-27	.10	150 kΩ (brown-green-yellow)
1-33	.10	470 kΩ (yellow-violet-yellow)

*Factory selected. Only one of these three resistors is used in your Recorder. Order same value as original.

Other Resistors		
(2) 1-19-1	.10	220 Ω 1 watt (red-red-brown)
1-9-1	.10	10 kΩ 1 watt (brown-black-orange)
(3) 1-24-2	.15	100 kΩ 2 watt (brown-black-yellow)
(4) 2-227	.45	550 Ω metal film
2-228	.45	2 kΩ metal film

PART No.	PRICE Each	DESCRIPTION
CONTROLS		
(5) 10-168	.80	500 Ω
(6) 11-87	.65	1000 Ω





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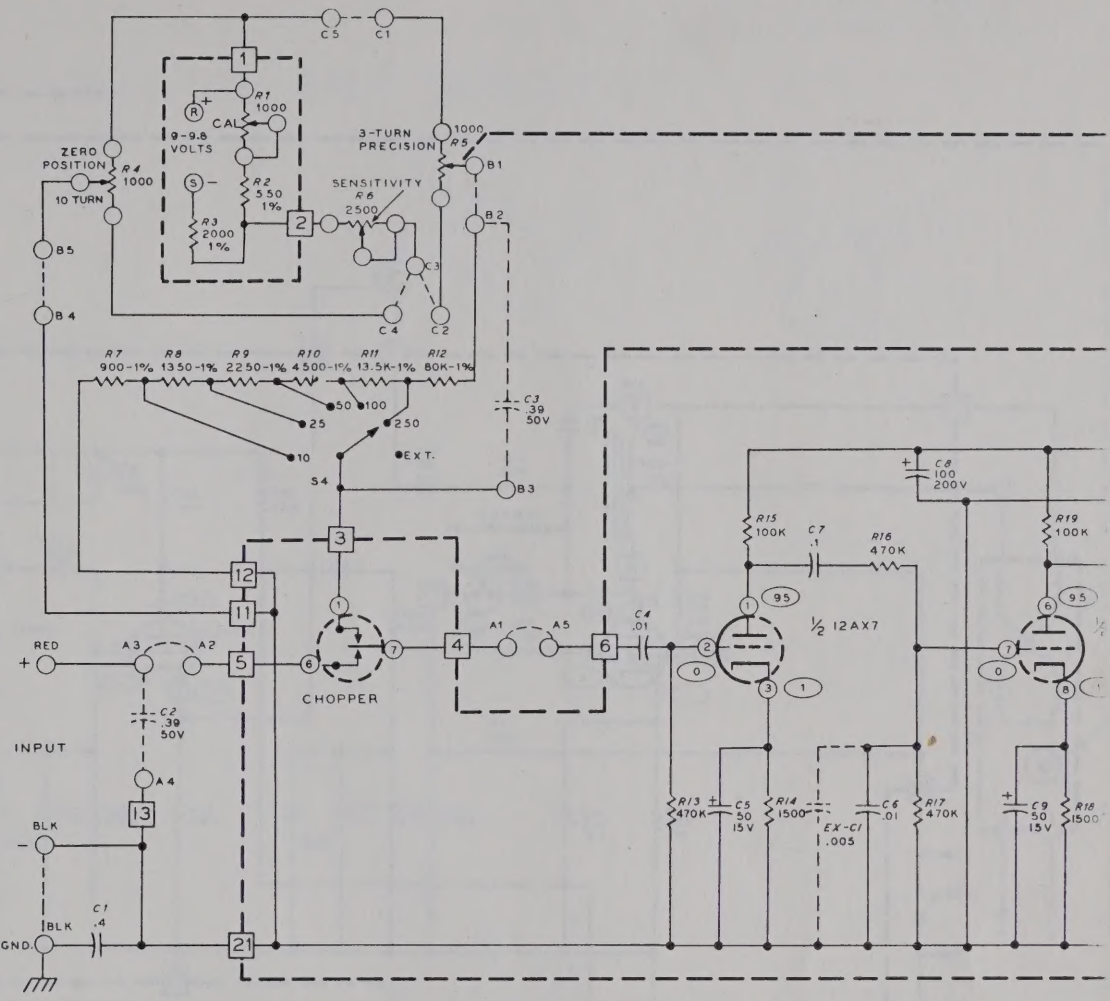
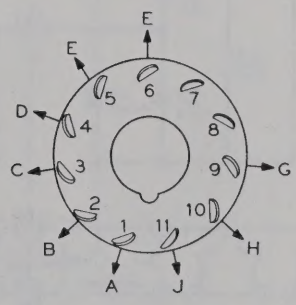
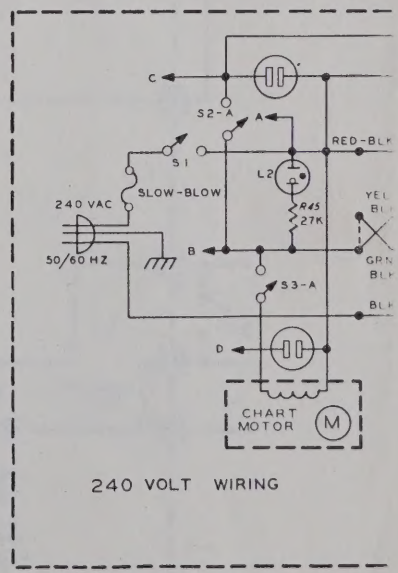


SCHEMATIC OF THE HEATH SERVO-RECORDER MODEL EU-20B

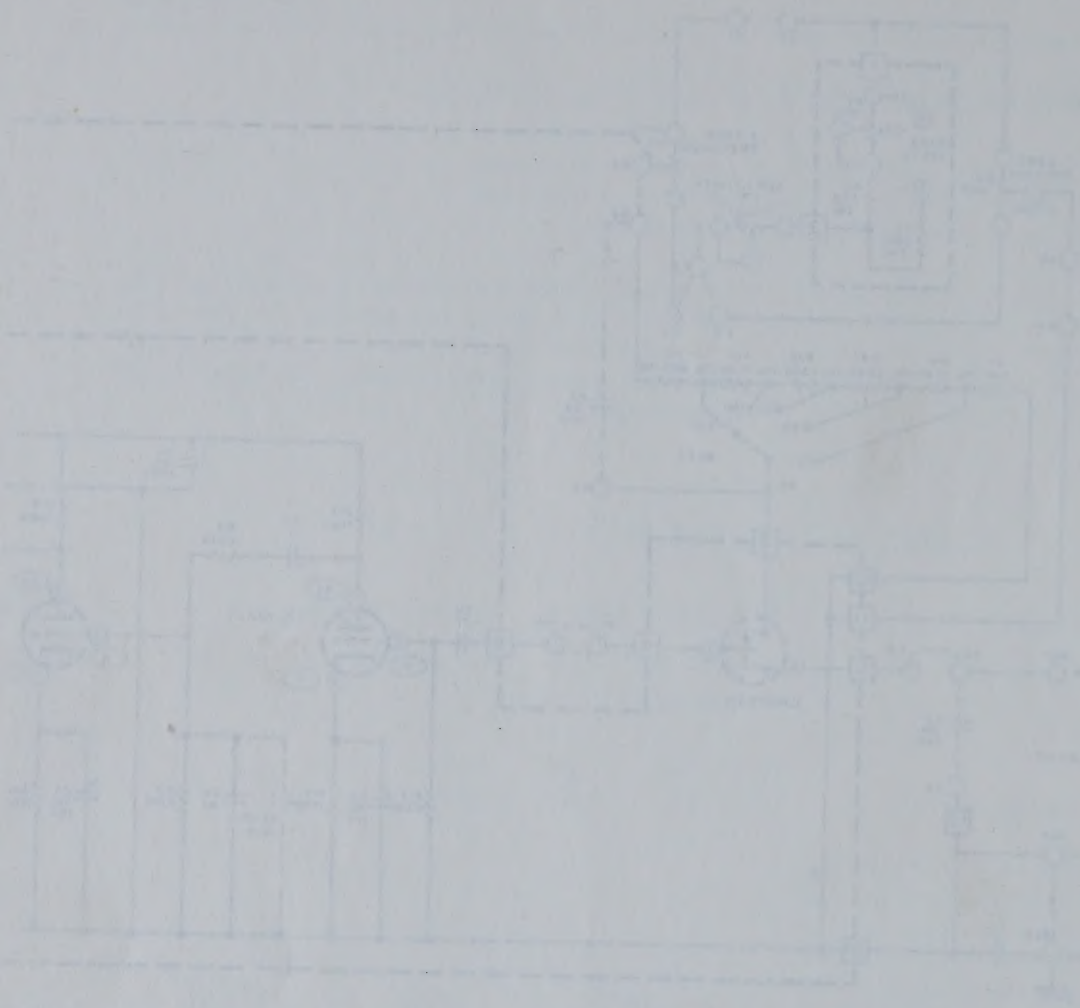


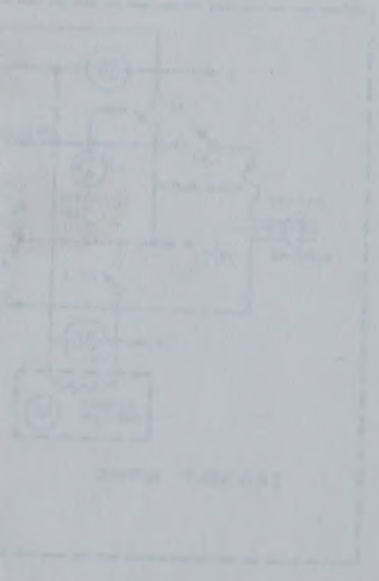


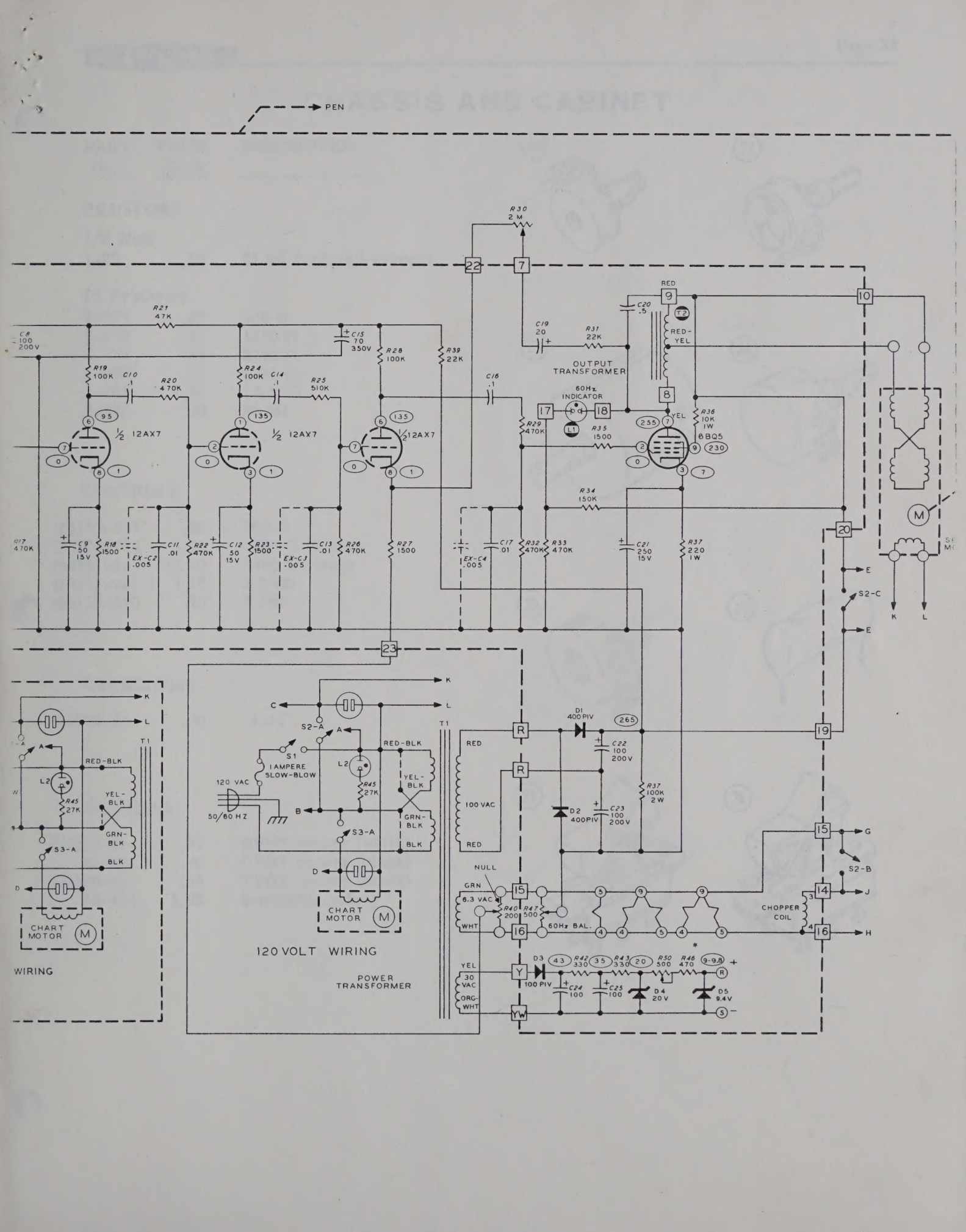
240 VOLT WIRING

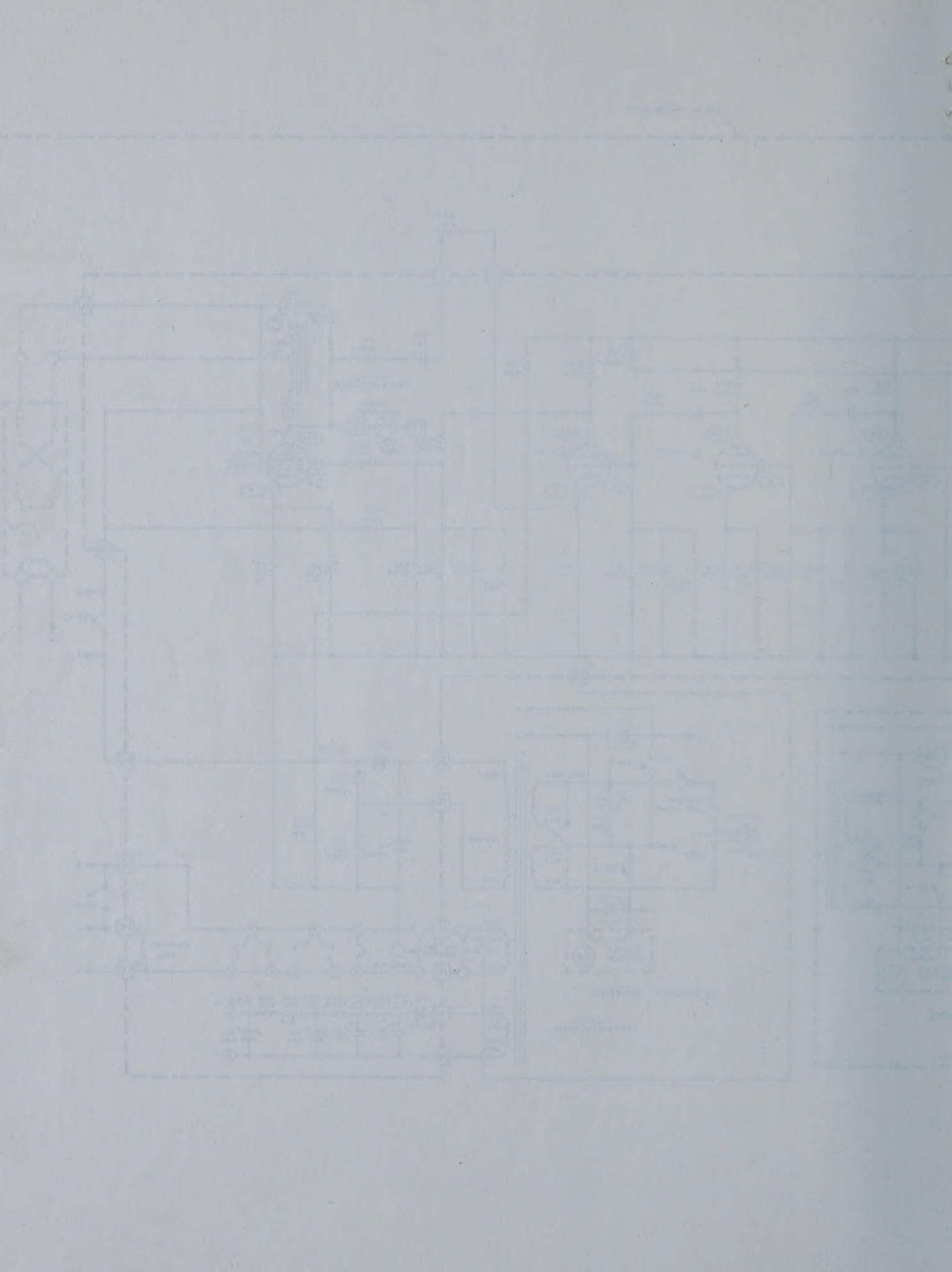
NOTES:

1. S1 - POWER SWITCH
   S2 - SERVO SWITCH
   S3 - CHART SWITCH
   S4 - RANGE SWITCH
2. 11-PIN ACCESSORY SOCKET VIEWED FROM INSIDE CHASSIS
3. ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE.
4. ALL RESISTOR VALUES ARE IN OHMS(K=1000, M=1,000,000).
5. ALL CAPACITOR VALUES ARE IN μF.
6. ⬭ INDICATES A VOLTAGE MEASUREMENT FROM POINT INDICATED TO COMMON NEGATIVE ON THE CIRCUIT BOARD, EXCEPT FOR AC VOLTAGES ON THE POWER TRANSFORMER AND DC VOLTAGES ON THE ZENER REFERENCE SUPPLY.
7. VOLTAGE READINGS TAKEN WITH AN 11 MEGOHM INPUT VTVM WITH THE CIRCUIT CONNECTED AS SHOWN. INPUT SHORTED, SYSTEM BALANCED, SERVO POWER ON.
8. CAPACITORS SHOWN WITH DOTTED LINES ARE FOR 50 Hz OPERATION ONLY.
9. ⛀ INDICATES COMPONENTS NOT ON CIRCUIT BOARD.
10. R1, R2, AND R3 ARE ON THE CIRCUIT BOARD.
11. * SELECTED AT FACTORY MAY BE 680, 720, OR 820 OHMS DEPENDING ON ZENER DIODES.
12. EX-C1, EX-C2, EX-C3, AND EX-C4 ARE CAPACITORS WHICH ARE INSTALLED IF THE SERVO-RECORDER IS TO BE USED WITH 50 Hz LINE FREQUENCY.



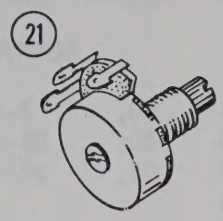


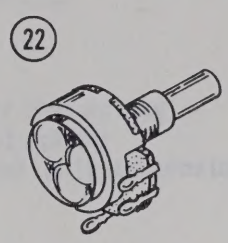

PEN
R30 2 M
R21 47K
C8 100 200V
C15 70 350V
R28 100K
R39 22K
R19 100K
C10 .1
R20 470K
R24 100K
C14 .1
R25 510K
C16 .1
½ 12AX7
½ 12AX7
½ 12AX7
C19 20
R31 22K
C20 .5
RED
RED-YEL
OUTPUT TRANSFORMER
60Hz INDICATOR
R29 470K
R35 1500
YEL
R36 10K 1W
6BQ5
R34 150K
R17 470K
C9 50 15V
R18 1500
EX-C2 .005
C11 .01
R22 470K
C12 50 15V
R23 1500
EX-C3 .005
C13 .01
R26 470K
R27 1500
EX-C4 .005
C17 .01
R32 470K
R33 470K
C21 250 15V
R37 220 1W
S2-C
E
K
L
M
120 VOLT WIRING
POWER TRANSFORMER
S1 1 AMPERE SLOW-BLOW
120 VAC
50/60 HZ
S2-A
S3-A
L2
R45 27K
RED-BLK
YEL-BLK
GRN-BLK
BLK
CHART MOTOR
D1 400PIV
C22 100 200V
D2 400PIV
C23 100 200V
R37 100K 2W
100 VAC
NULL
GRN
6.3 VAC
WHT
R40 200
R47 500
60Hz BAL.
CHOPPER COIL
S2-B
G
J
H
D3 100 PIV
R42 330
R43 330
R50 500
R46 470
C24 100
C25 100
D4 20V
D5 9.4V
YEL
30 VAC
ORG-WHT
WIRING

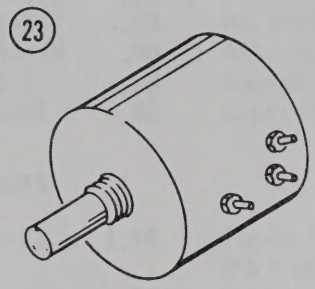


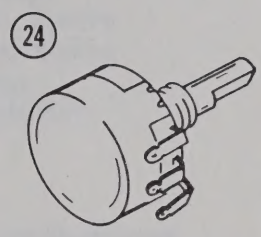
CHASSIS AND CABINET

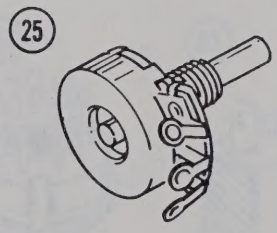
PART No.	PRICE Each	DESCRIPTION
RESISTORS		
1/2 Watt		
1-23	.10	27 kΩ (red-red-orange)
1% Precision		
2-277	.20	900 Ω
2-278	.20	1350 Ω
2-279	.20	2250 Ω
2-280	.20	4500 Ω
2-281	.20	13.5 kΩ
2-282	.20	80 kΩ
CONTROLS		
(21) 10-237	.50	200 Ω
(22) 10-239	1.60	1000 Ω 10-turn
(23) 11-48	11.10	1000 Ω 3-turn
(24) 11-92	1.15	2.5 kΩ
(25) 10-240	.70	2 MΩ
CAPACITORS		
(26) 27-20	.30	.4 μF
SWITCHES		
(27) 60-31	.60	DPDT rocker (white)
60-32	.70	DPDT rocker (black)
(28) 60-40	.85	TPDT rocker (black)
63-484	1.65	6-position rotary

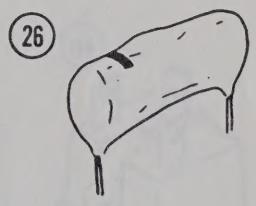


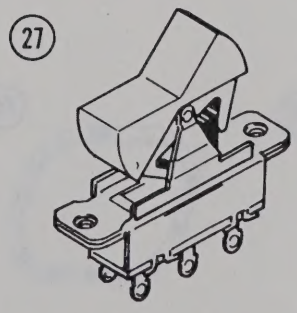


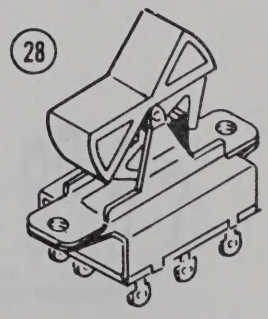






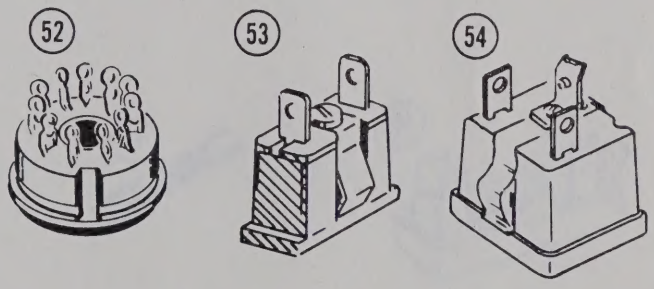


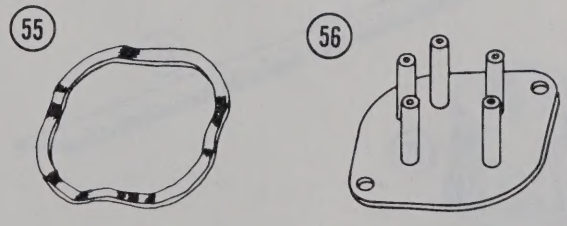




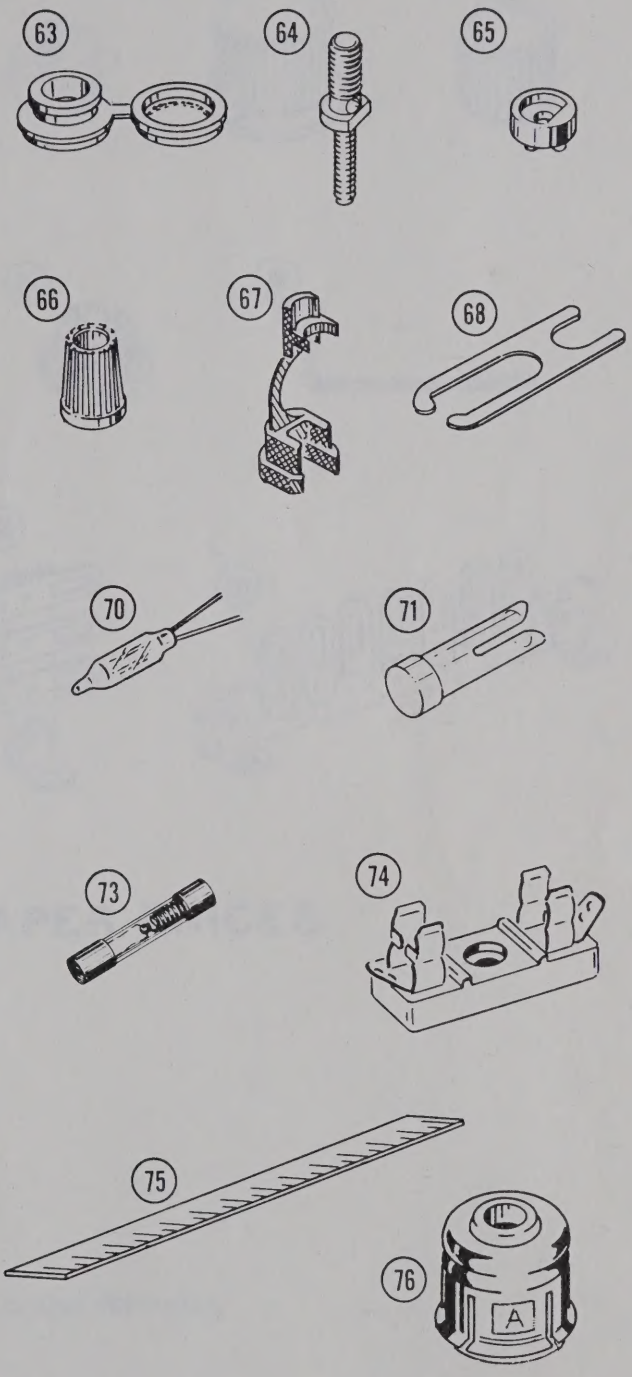
PART No.	PRICE Each	DESCRIPTION
HARDWARE		
#6 Hardware		
250-56	.05	6-32 x 1/4" screw
250-89	.05	6-32 x 3/8" screw
250-29	.05	6-32 x 3/4" screw
250-13	.05	6-32 x 1" screw
250-170	.05	#6 sheet metal screw
252-3	.05	6-32 nut
252-27	.10	6-32 locknut
254-1	.05	#6 lockwasher
259-1	.05	#6 solder lug
259-11	.05	#6 spade lug
Other Hardware		
250-52	.05	4-40 x 1/4" screw
250-105	.05	8-32 x 1/8" setscrew
(29)250-271	.15	Adapter stud
(30)252-7	.05	Control nut
(31)252-22	.05	Speednut
253-10	.05	Control washer
(32)253-36	.05	Spring washer
(33)253-49	.05	Nylon washer
253-60	.05	Steel washer
(34 253-73	.05	Rubber washer
253-80	.05	Steel washer
(35)254-5	.05	Control lockwasher
255-23	.05	15/32" spacer
(36)255-84	.05	Shoulder spacer
259-10	.05	Control solder lug
(37)453-53	.10	Pin
METAL PARTS		
(38) 90-396	5.00	Cabinet base shell
(39) 181-55	5.00	Chart drive unit
(40) 181-52	3.55	Writing panel
(41) 181-53	2.45	Access panel
(42) 181-54	1.50	Back panel (with pins)
(43) 200-514	2.00	Chassis
(44) 203-521	.85	Drive panel
(45) 204-583	.25	Drive shaft mounting bracket
(46) 204-840	.20	Roll support bracket
(47) 204-958	.25	Rocker switch bracket
(48) 266-104	.20	Pen carriage

PART No.	PRICE Each	DESCRIPTION
SPRINGS		
(49)258-1	.05	Pen holder coil spring
(50)258-62	.05	Clutch coil spring
(51)258-96	.50	Drive cord hairpin tension spring
SOCKETS-CONNECTOR		
(52)434-118	.40	11-pin socket
(53)434-147	.20	AC socket, 2 wire
(54)434-148	.30	AC socket, 3 wire
(55)435-1	.10	Socket ring
(56)432-51	.40	5-pin connector
GEARS		
(57) 451-56	1.45	Paper drive shaft gear (25 tooth)
(58) 451-57	1.60	Motor gear (25 tooth)
451-60	2.35	Motor gear (30 tooth for 50 Hertz operation)
(59) 451-58	1.30	Paper drive sprocket



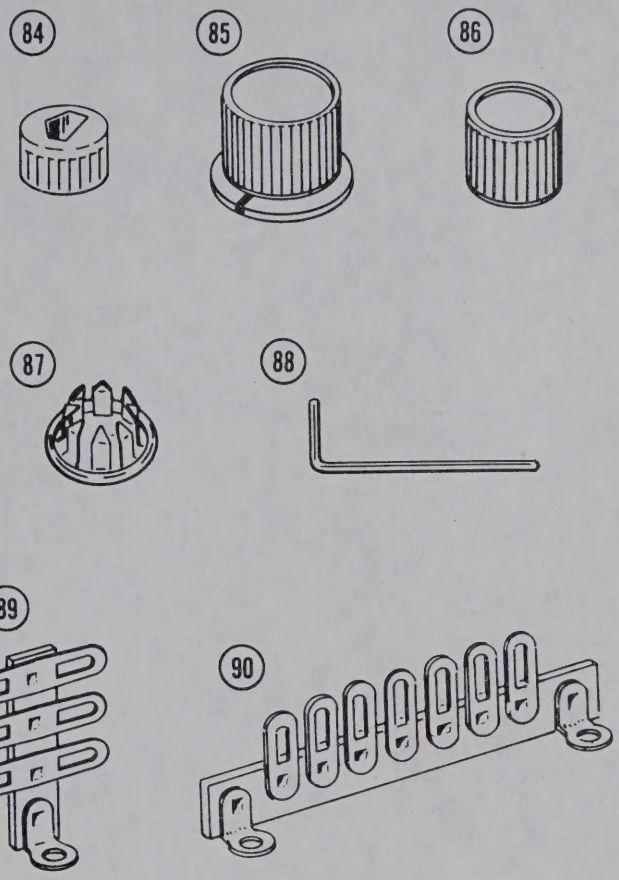


PART No.	PRICE Each	DESCRIPTION
PULLEYS		
(60) 466-19	.55	Motor pulley
(61) 466-20	.80	Control pulley
(62) 466-25	.25	Idler pulley
MISCELLANEOUS		
51-99	3.60	Output transformer
54-204	5.00	Power transformer
(63) 73-43	.10	Grommet
(64) 427-3	.10	Binding post base
(65) 75-17	.10	Binding post base insulator
(66) 100-16-2	.10	Binding post cap (black)
100-16-18	.10	Binding post cap (red)
(67) 75-30	.10	Strain relief
75-71	.10	Strain relief*
89-23	.75	3-wire line cord
(68) 212-22	.40	Shorting strap
(69) 261-17	.05	Foot
349-1	.10/ft	Dial cord
406-23	1.35	Pen
406-44	1.45	Dust cover
(70) 412-15	.20	NE-2H lamp
412-36	.20	NE-2E lamp
(71) 413-10	.10	Red lens
413-11	.10	Clear lens
(72) 420-22	26.20	Pen motor
(73) 421-23	.30	1 amp slow-blow fuse (120 VAC)
421-20	.30	1/2 amp slow-blow fuse (240 VAC)
(74) 422-1	.25	Fuse block
(75) 445-12	.15	Scale chart
445-12-1	.15	Scale chart screen
A, B, and C PLUGS		
(76) 181-7	1.25	A plug
consisting of		
27-50	.40	.39 μF capacitor
434-11	.30	5-pin socket
440-1	.20	Plug cap
181-8	1.25	B plug
consisting of		
27-50	.40	.39 μF capacitor
434-11	.30	5-pin socket
440-1	.20	Plug cap
181-9	.75	C plug
consisting of		
434-11	.30	5-pin socket
440-1	.20	Plug cap



*This strain relief is supplied to be used in areas mainly outside the U.S. where round line cords are required.

PART No.	PRICE Each	DESCRIPTION
Miscellaneous (cont'd.)		
(77) 453-119	1.00	Pen carriage shaft
(78) 453-160	.45	Paper drive shaft with flat
(79) 453-163	.25	12-7/16" roll chart shaft
(80) 455-6	.10	Brass bushing
(81) 455-44	.10	Nylon bushing
(82) 455-45	.30	Paper roller bushing
(83) 455-15	1.35	Collar
(84) 455-50	.10	Knob insert
(85) 462-264	.35	Knob
(86) 462-279	3.40	Knob
(87) 485-2	.10	Plug button
(88) 490-6	.10	Allen wrench
(89) 431-4	.10	3-lug terminal strip
(90) 431-35	.10	7-lug terminal strip
	2.00	Manual (See Page 1 for part number.)



EU-20B CHART PAPER PRICES (EUA-445-8)

Quantity	Price
1-9	4.50
10-24	4.25
25-99	3.75
100-199	3.25
200-500	2.75

Write for prices on orders exceeding 500 rolls.